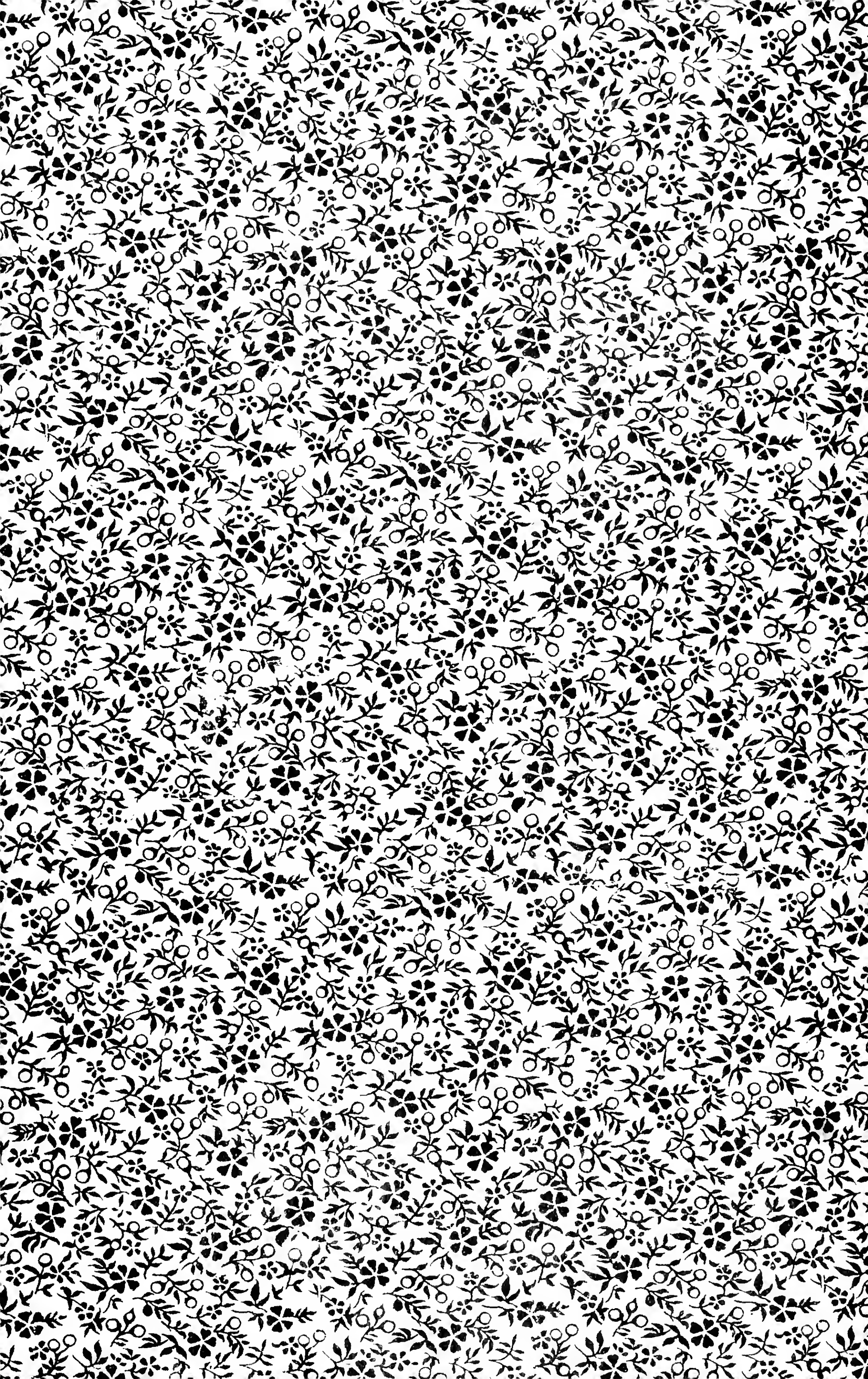

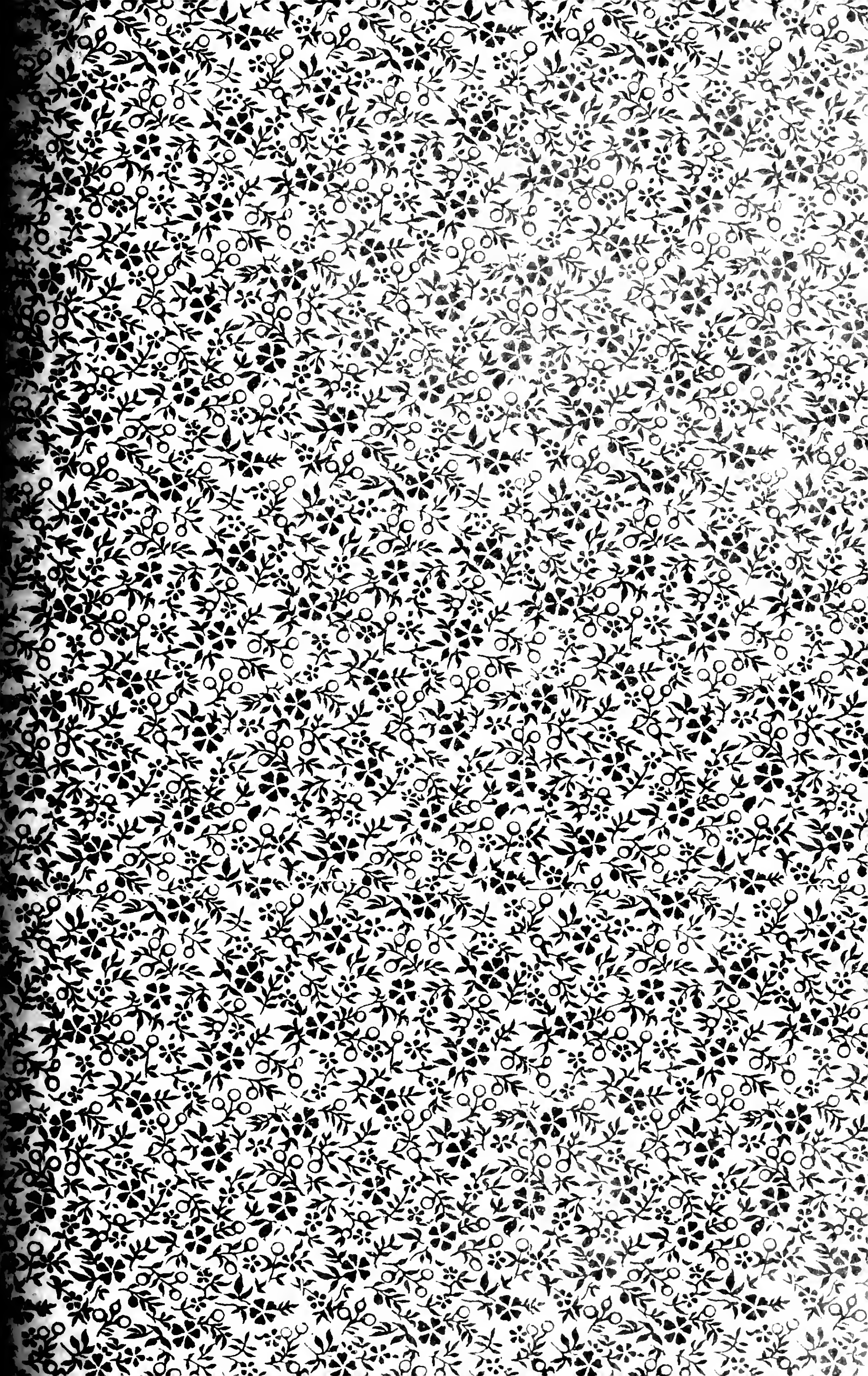

PROCEEDINGS

OF THE

THIRTIETH ANNUAL CONVENTION

OF THE

American Railway Engineering Association

HELD AT THE

PALMER HOUSE, CHICAGO, ILLINOIS

March 5, 6 and 7, 1929

VOLUME 30

A

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BUSINESS SESSION

PROCEEDINGS

The object of this Association is the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railways. Its action is not binding upon its members.

TUESDAY, MARCH 5, 1929

MORNING SESSION

The Thirtieth Annual Convention of the American Railway Engineering Association was called to order in the Grand Ball Room of the Palmer House, Chicago, Illinois, by President W. D. Faucette, Chief Engineer, Seaboard Air Line Railway.

The President:—The meeting will please come to order.

This is the Thirtieth Annual Convention of the American Railway Engineering Association. This meeting is also the annual session of the Construction and Maintenance Section and of the Electrical Section of Division IV—Engineering, American Railway Association. We function together as an instrumentality of the American Railway Association.

The first order of business is the approval of the Minutes of the last meeting. Inasmuch as these have been printed and are in your possession, if there is no desire to read them, they will stand approved. It is so ordered.

It is the custom, and it is proper, that the Chief Executive Officer of this Association make to you some remarks. Probably they are not always short enough to please you, but at least they are required, and if you will bear with me, I shall present to you a few observations.

ADDRESS OF THE PRESIDENT, W. D. FAUCETTE

Fellow-Members of the American Railway Engineering Association and Our Guests:

We are gathered together again for our three-day annual convention after an absence of one year. This meeting begins the Thirtieth Annual Convention of our Association, and it is with great pleasure that we welcome you here this morning. It will be my purpose briefly to touch upon some of the matters that we hope may be of interest to the Association, before we take up the regular order of business. It is gratifying to see the number present today. I will not trespass long upon your time.

You will receive the annual report of our Secretary, which will deal in some detail with the various functions of our Association and which is prepared in such way as to enable you to grasp quickly the activities, operation, membership, financial and general situation of our Association.

(In a lighter vein, I might say that due to the varied topics which the President has special privilege to include in his address, at least his remarks have one advantage—that while of necessity they may be disconnected, and the last part of his speech may not be affected by any contagion affecting earlier paragraphs, any member has the advantage of coming in at any part of this address and from that point on lose nothing of the thread of the story by the hour of his arrival. It has occurred to me that possibly in view of such varied subjects as this address includes, it might not be inappropriate for the President to deliver his address in sections, and divide it into three parts, delivering one-third on each morning of the Convention, and in this way spread the feeble efforts of his delivery to all who may be willing to listen, but upon an examination of the twenty-nine volumes of our fast growing Proceedings, the flexibility of the backbone of the speaker is so rigidly held by the usual path of precedent, that he yields to what has been done and proceeds in due and proper form.)

APPRECIATIONS

First, it is proper that due consideration and acknowledgment should be made of the co-operation and help received from the entire membership, with special reference to the twenty-eight committees and to the Board of Direction, on whom devolves the regular administrative work of our Association. No one who has had the executive direction of the Association can fail to be impressed with the earnestness, interest and zeal which is put into this Association's work, and keeping in mind that it is done voluntarily, with the achievements and results of effort to be largely the reward of the undertaking, I feel the entire membership has justifiable pride in what has been done and is being currently accomplished.

Special reference should be made again to the excellent and painstaking work of our Secretary. It has been my great pleasure to have been constantly associated in this work for the past twelve months with Mr. Fritch. The Association does not always realize that fund of knowledge and excellence of judgment with which he is always ready to help the current administration and keep its affairs on an even keel.

MEMBERSHIP

In the past twelve months it is a pleasure to report the gross addition to membership amounts to three hundred and twenty-five. This has been accomplished by the help and assistance of many of the members throughout Canada and the United States and the result of a quiet campaign which has been undertaken for increased interest in the Association. I am sure this increase in membership will continue, and at this time I would like to impress upon all the members old in service to welcome to this convention the new faces that will be here during the sessions. There is no qualification in the opportunity afforded by membership, as all are engaged in one general object, and that is *the advancement of knowledge pertaining to the scientific and economic location, construction, operation and maintenance of railroads,* and while we shall give the next three days to the review and consideration of the excellent reports which have reached you in the form of Bulletins, I cannot but dwell briefly upon that great measure of benefit and education which comes out of personal contact which this convention offers to its membership. If it were not so then we might reduce our exchange of ideas to a correspondence method, and reach our conclusions by mail or solely in committees, but there is nothing so broadening and helpful as personal contact and exchange of ideas with those who are engaged in the same or related work, and without doubt much of the great good that has been derived from this Association has been through personal contacts and acquaintances which have ripened in a vast number of instances into those friendships which are so highly prized in any man's career. Education and enlargement of vision, the impression brought about by new ideas thus gained is very often from these contacts which are made possible by these yearly meetings. Therefore, to the new members who are now coming the first few times to this convention, I say, be not reluctant to meet or acquaint yourself with other members who will be pleased to know you. To this kind of benefit that grows out of these meetings I want to bear the highest testimony, and let it be realized fully in assessing the value that this Association is, or will be to you.

The Constitution provides certain requirements and methods for the election of Honorary Members of the Association. No names have been submitted, nor any such elections made during the past one year. At this time we have one Honorary Member on our roll.

PUBLICATIONS

Your attention is drawn to the publications of the Association during the past year. In addition to the Bulletins, which have been issued covering the committee reports made to the convention, there have been other and miscellaneous publications, such as the New England Flood Report, the report on Mechanical Wear of Cross-Ties, the Past-Presidents' Bulletin, Specifications for Steel Highway Bridges, and Mr. W. C. Cushing's report on "The Rail and Wheel."

All of these contain information and observations of the highest quality and the Association is adding to its great fund of knowledge every year. A library of the publications of our Association is replete with data which I do not feel is duplicated elsewhere. I dare say without fear of contradiction, that we have accumulated the most comprehensive array of information and observations and reduced them to a systematic presentation as excellent as any other similar engineering association work in existence. The preservation of your publications is deserved.

OUTLINE OF WORK AND PERSONNEL OF COMMITTEES

While touching upon publications, it is appropriate that I should call attention to the success this year of the Committee on Personnel and the Committee on Outline of Work of the Board of Direction in getting out the committee work assignments for next year as early as was done. This booklet has been issued and is now in service and use.

Before leaving this subject your attention is invited to the Bulletins, and on the first page thereof to the various committees of the Board of Direction, viz., Finance, Publications, Library, Outline of Work, Personnel of

Committees, Special Committee on Manual and the Committee on Membership, and a committee (not of the Board of Direction) known as the Committee on Arrangements, to which this Association is due a full measure of appreciation. The general direction of this Association (and many other matters that arise for settlement) is carried on through the administrative aid and instrumentality of those men, and I have invited the members of the Board of Direction who are present today, to sit here at the speaker's stand while I am making these few remarks. It has seemed to me that it is appropriate that these men should be known personally to all of you, and in paying high praise to the twenty-eight working committees, I would be failing in duty if I did not record here the excellent work accomplished under the direction of these administrators, your Board of Direction. At the close of my remarks I shall pause a moment so if any of the Directors desire to make any remarks concerning the work under their special direction, they will be appropriate at this time.

COOPERATION WITH OTHER ORGANIZATIONS

The Association has received many invitations during the past year to attend or send representatives to certain meetings or events. In July, at Louvain University (Belgium) at the dedication of the library, we were represented by Dr. W. K. Hatt, of Purdue University.

The Association was invited to send a representative to the World Engineering Congress in Tokio, Japan, this year. I am pleased to say that the Board of Direction has named Mr. Fritch, our Secretary, to represent us at Tokio, and he will go to the Orient in the fall. Next year we hope to have Mr. Fritch tell of his trip and give us an interesting report.

The Southern Forestry Congress met in Atlanta, Ga., in October, 1928, and our representative was W. L. Morse, of the New York Central. I cite these three, but we are at all times receiving current invitations, and where possible, it is our policy to send representatives from whom we receive proper reports.

DECEASED MEMBERS

It is with great regret and sorrow that we find it necessary in the recording of facts to mention the number of deceased members, totaling thirty-four, during the past twelve months. The list is set out in detail in the Secretary's report which will follow. Among those listed, I would like to mention at this time the loss of Edwin B. Katte, former Chief Engineer Electric Traction of the New York Central Railroad and Chairman of the Electrical Section of the American Railway Association. Mr. Katte's loss, in view of his many activities, is keenly felt and we pay tribute to his memory today.

I also pay tribute to the memory of the late John B. Berry, a former Director of our Association; Howard G. Kelley, Past-President of our Association and former President of the Grand Trunk System; E. J. Pearson, former President of the New York, New Haven & Hartford Railroad Company; Howard Elliott, Chairman of Board of Northern Pacific Railway, and A. F. Robinson, former Bridge Engineer of the Atchison, Topeka & Santa Fe Railway Company, and to all of our deceased members I pay a corresponding tribute.

THE PAST, THE PRESENT AND THE FUTURE

Now we come to some consideration of the present age. It is with great difficulty that we can attempt to vision the future. Since 1890 marked increase in all lines of industrial, scientific and transportation activities is probably without parallel in the history of the world. These forty years have witnessed such achievements within the retrospect of our own recollection that if you attempt to project yourself into the future, where we will reach and what will be our experiences, I do not believe we can reasonably forecast. The door of the future stands slightly ajar and the outlook, which we cannot see clearly, is before us. Surely Tennyson in his quotation had at least some vague idea: "Men, my brothers, men the workers, ever reaping something new, that which they have done but earnest of the things that they shall do," and later in that same poem he said: "Not in vain the distant beacon beckons, forward, forward let us range—let the great world spin forever down the ringing grooves of change." This was in 1842 and we are still engaged in new accomplishments each year.

However, in so far as the progress of the transportation world shall continue, so also shall the responsibilities of our Association increase, and the duties and solution of problems of economics and justified practices, become more pressing upon us. In this time which we must acknowledge to be a period of transition, in which considered even alone in the sphere of motor transportation, it is of paramount importance that the efforts of ours and allied associations should be in the direction by which the economies to be effected and solutions of problems reached will enable us as an agency of transportation to say what will help produce a satisfactory service and economically, which production shall bring a reasonable return to the owner. This one idea shall ever be before us in a searching for the proper answers.

MOTOR TRANSPORT

It will not be amiss to touch briefly upon the motor transportation of this country, and the increasing air transportation efforts. In the matter of affecting the heavy tonnage movement of railroads, I believe we can for the present defer consideration in regard to this air transport having much adverse effect upon the main revenues of our railroads. I fully believe that with the remarkable records that are being made month by month, the field of quick transport by air will be, however, confined chiefly to those articles of high intrinsic value such as mail, securities, small but important parcels, and human freight, but not of large tonnage. This would tend to make the air transportation service one not so actively making inroads in the business of trunk line carriers in any degree comparable now, or in the future, to that which has been brought about through the present and ever increasing motor transport operations. This problem of motor transport is not a matter or reckoning with an organization in the sense of an opposing competitor, or group of competitors. We have surely reached a place in our civilization where a new instrumentality has become a part of the regular composition of our life—it has changed business, social and civic customs and created a changed condition—a fact and not a theory. In some way the situation will be met.

EFFECT OF HIGHWAY TRANSPORT

This impetus to public roads, which is now but in the middle stages of progress, has as you know affected adversely the revenue business of our rail carriers, and thereby imposed upon us most seriously the importance of proper solution of problems of economics that we may carry on and perform service by our railroads economically and meet the new situation. I dare say there is hardly one within the sound of my voice who is not impressed with the growth of the motor industry. Statistics are at best a burden, but in 1921 in round numbers, there were 10,000,000 motor vehicles registered in the United States. In two years this went to fifteen million, and in four years more it reached twenty-three million, or at the present time one motor vehicle for about every five persons. (In this list were about three million motor trucks and road tractors and 125,000 trailers.) In 1928 we produced one million more passenger automobiles than in 1927.

CONSTRUCTION OF PUBLIC ROADS

Running in parallel with this comes the question of public roads. In 1918 we had about 300,000 miles of surfaced country and rural roads. In 1928 this was nearly doubled to 590,000 (January, 1928) (of which nearly 100,000 miles are hard surfaced), and there is a coordinated national system (Federal Aid) of roads at present which is 188,000 miles. The State Highway Systems are about 295,000 miles and interstate marked system of nearly 97,000 miles. The total mileage of our rural roads in the states is about 3,000,000 of all classes, and in the past ten years some six billion dollars have been spent on rural roads in the United States. We cannot deny the convenience of quick local transportation by passenger and freight motor transport from location to location, and we cannot diminish the excellence of the State and Federal highway systems that are being constructed, which in themselves have been achievements worthy of highest engineering approbation. In the Southeast alone it is interesting to point out that the state of North Carolina has spent approximately $150,000,000 in the last few years on a carefully worked out system of highways. The bridges alone in this vast United States highway system are in themselves, in many instances, large and notable undertakings, for example, Kill Van Kull Bridge at New York and highway bridge over Hudson River, the Charleston, S. C., bridge, the James River bridge and the highway bridge at Cairo and "Chain of Rocks" on the Mississippi, also the highway bridge, Louisville, Ky., and the Lee's Ferry arch bridge over the Grand Canyon of the Colorado River in Arizona. These recited places but set out the changing picture for your reflection and your consideration.

ECONOMICS

In the broadest aspect of the case, engineering is but science applied to industry and we are seeing developed before us in remarkable strides without parallel in the history of human achievement, the construction of roads and the building of motor vehicles, using them to an extent greater in percentage than in any other single industry in this country. This is not only true in extent of mechanical units, but likewise measured in volume of increasing investment. This is an interesting problem inasmuch as the construction of roads encourages the production of vehicles and in turn the vehicle encourages the increase in road mileage. No one would detract from the convenience and pleasure and benefits that this accomplishment affords the human race, consistent of course, with the broad economic policy that taxation caused by such special privileges may not place upon the body politic a burden in excess of the economic benefits that may be derived by road building in question, but be that as it may, the problem keenly affects the industry in which those of us here are primarily engaged. Transportation by these new arteries of commerce, with its motors, will of course in time call for the proper and just regulation and coordination. Undoubtedly with a better knowledge of the situation, both with respect to the burden of taxation and maintenance and with whatever effect it may have upon great rail transportation lines, reasonable regulation will come about. However, if growth in this industry is as great in the future as it has been in the past (and it will probably be large) the inroads made by taking for transport the tonnage of these vast rail carriers is such as will call for the best brains and talent of this country to meet this situation, either in coordination or economic competition. At the present time in many localities the short-haul rail movements, both freight and passenger, is rapidly diminishing. The rail lines must study more intensely the problems of economics that will meet the heavy inroads made by these motor instrumentalities. Therefore, this Association cannot escape and does not shirk the duty of study in every aspect whatever, such economies as may be necessary to help bring about the operation that will meet the reduced tonnage and competition affected by this vast system of interstate highways to which I have referred. Already the operation of air service in connection with our passenger service is an indication of the future development on the part of the railroads to keep in touch with the modern growth of transportation. The air coordination will be popular, but as to heavily affecting tonnage, I believe not. The situation must and can be met by the railroads and while undoubtedly the abandonment of certain zones of non-productive lines must and will take place, still the problem of economics in the major part of the country will be for study and review for years to come. I dare say that while we will have certain rail line construction always in the future, last year very little more mileage was authorized to be constructed by the Interstate Commerce Commission than was authorized to be removed. New construction per year has been practically less than 1,000 miles in the United States since 1914 and the average is 714 miles per year for fourteen years. The mileage abandoned last year was about 512 miles.

NOTABLE ENGINEERING PROJECTS

But with this picture of this great highway transportation system being developed while rail workers look on, our business still justifies engineering improvements, and marked accomplishments have been made, and while it is impossible to go into details in this large country of ours, it is but right we should record certain important construction items in railroad and allied work accomplished in the past year or two. Let me not forget to attract attention to the Cascade Tunnel on the Great Northern, the Moffet Tunnel in Colorado, the first being nearly eight miles long and the longest in America, the second over six miles long. These tunnel projects form highly interesting reading and worthy of your special consideration; many working records were established, and each of the projects cost, as I recall, in excess of $15,000,000.

Other important items to which we may briefly refer are the electrification of certain parts of railroads in the United States, accomplished at the cost of millions of dollars. I mention the projects of the Great Northern, Pennsylvania, Lackawanna, Reading, New York Central and others.

New and modern railroad bridges—one across the Ohio River will be completed in a few months, replacing lighter structures such as those under construction by the Chesapeake & Ohio and the Big Four, and the combined highway-railroad bridge at Vicksburg, Miss., and the "Suisun Bridge" of the Southern Pacific in California.

Grade revisions and double track work such as undertaken on the Missouri Pacific and other roads, and some projects for extensive union passenger terminals in important centers under construction. Automatic signals on about 3,100 road-miles were put in in 1928, and it has been forecast that in 1929 more capital money will be spent on our railway systems than in 1928.

AMPLE SCOPE FOR FUTURE PROGRESS

This does not attempt to delineate all of the major work of railroads, but just to touch briefly as we pass. While we do not include in our Association work mechanical phases of railroad operation, still I am advised the largest locomotive ever built is just now to be placed in service on the Northern Pacific Railway, with a weight in excess of 1,000,000 pounds. These improvements and construction items in the railway world are not without some means greatly helping in the increased efficiency in railway operation. There have been huge capital expenditures made in the last several years and railroads have set up new records in operating efficiency. The fact that our managements have concluded to make these vast investments indicates the faith and confidence in engineering work and operating economies that are forecast by those engineering studies which justify these large investments. I think we may safely say without qualification that any project of note on any railroad is never undertaken until a careful analysis and painstaking effort to analyze the future results have been made. Surely our business, that of engineering construction and maintenance, is free from the emotions of life that may in their enthusiasm carry us off of our feet and cause us to do those things which a cool and meditated consideration of the problem would show to be unfortunate blunders. In short, these engineering decisions are results of calm calculations and conclusions and the efforts of this Association in its study of many of the problems and subjects coming under its scope during the past thirty years has contributed, I believe, in a very large measure to preventing unwise and unfortunate expenditures by the owners of our vast properties. Its work is not complete—facing the complexity and keen competition of the age the need for thorough work by our Association is just as pressing and will ever be, for with every problem there is a corresponding call for a sound conclusion.

In the past year the railroads have made splendid records in operating efficiency, the records of which are easily available to you. It is well to study the economic situation along with our engineering investigations.

In regard to certain accomplishments that deal not with construction I must refer to the transverse fissure detector car devised by the Sperry Development Company through contact with the Rail Committee and with the American Railway Association. The results thus far achieved have been more than was at first anticipated and we look forward to greater results from this direction. This marks a pronounced advance in this special subject.

RESEARCH

Among other work as may come within the scope of our Association in addition to the rail investigations and other research work of the several committees, all of which are splendid achievements, we must mention the work done by the Special Committee on Stresses in Railroad Track; the undertaking of bearing values of large rollers, and such other related items. I cannot but believe that in research work we have yet some field in which we can proceed with justification. We may be faced in the future with the question of new rail design and improvement, with the matter of changed or modified track structure, with laboratory experiments in the matter of materials for railway construction, possibly the use of more alloys, matter of economic substitutions, and, while not a laboratory experiment, the great problem of training of men for the future control and administration of railroad properties. This may not be a question for this Association to consider, but at this time with industrial developments and progress now apparently approaching its highest peak in the history of the world, we must not overlook the problem to be sponsored by some institution of the proper training of men for contact with each other and for the reception of the heavy responsibilities which must devolve upon them in the next twenty-five to fifty years. This problem involves so many phases and touches so deeply into the question of personality that as I look into the many avenues of intense specialization, I would put forward as of primary importance the need for railway officers and executives, and particularly for consideration in our work and related work—to not overlook the necessity for encouraging initiative and developing talent, so as to insure that broadminded and properly equipped administrators will evolve with the necessary wide experience to handle successfully the properties which this Association in its particular sphere is attempting to build, improve and economically operate and maintain.

I trust I may be pardoned for thus digressing here, but we cannot escape this question in our consideration of the future of railways, and while it may not be classed as engineering, certainly it is "human engineering" in the sense of building up personality to deal, not only with engineering and operating problems as abstract things, but who must always deal simultaneously with the human side of the question. We are interested in such as a broad railway problem.

THE ASSOCIATION'S OPPORTUNITY

We come now to next year's work. I am terminating a year in this office with a flood of pleasant memories and with the intensified feeling of great respect and admiration for the membership of this Association. Much has been accomplished and more is yet to be done. This Association is a school and education to those in the mood to receive it. No man is too old to learn, and you will at the close of this three-day session leave with new subjects assigned and subjects to carry to conclusion. May I repeat without fear of weakening the effect, that I desire to impress upon you the importance of the work that has been accomplished during the past year. In looking over the great field of endeavor and in contemplation of the vast data that has been accumulated in the past thirty years, I trust that I may not be misunderstood when I say that I believe it is well that we balance carefully in our Association work, the two parts of our general efforts. What I mean to convey just here is, that we, as an Association, are engaged through our committees in a great deal of fact-finding operations, accumulation of data and recording them in a concise and historical way. Now in order that we may.deduce from this effort spent in fact-finding and observations, I feel we must be sure as a body, both in committee work and speaking in a collective sense, that we plan our work of reaching proper conclusions and establishing principles of recommended practice with the same relative assignment of weight to these two points as will give an equal value to both the efforts spent in the accumulation of data and the efforts spent in deriving principles and making engineering deductions. Let us not overbalance these two functions in our Association work, that without such balance we may have in our files a storehouse of information that may not be well assimilated. I feel in the past we have well-balanced this situation, but with the present modern methods and facilities by which we may accumulate data from all channels, let us ever keep before us the fact that I have just expressed, balance deduction with accumulation of data.

REVISED MANUAL

We expect this year that the new Manual will be issued. It represents the progressive accumulation of work of this Association for the past thirty years. It is commended to your careful consideration. It is unique in that I doubt if so many persons have ever been co-authors of one volume, and as far as may be practicable, may your effort be in following to some degree the standards set out in this Manual of Recommended Practice. It is appreciated that the individuality of various railroads prevent the acceptance of this Manual fully in detail, but with the force and encouragement of this Association behind it, it is believed that this Manual will become more and more specified for uniform practice and uniform design. Will you not take it under consideration in your work from month to month and attempt to encourage the use of such recommended practices as appropriately fit your property?

IN CONCLUSION

And now we come to the close. Your attendance here at these daily sessions is appreciated. Your close attention is justified to the reports which have been received and which are to be delivered. We are in the main confronted with a world of industrial and engineering advancement. Never before have we needed to be more alert and more thorough and nearer right in our conclusions. We are the "heir of all the ages, in the foremost files of time." We have not been found wanting, and I know that we will carry on with an efficiency appropriate to the standing of this, our Association. (Applause.)

The President:—The next order of business is the reports of the Secretary and Treasurer, which we will now have.

Secretary E. H. Fritch:—Fellow-Members of the American Railway Engineering Association: It has been said that the story of the Creation of the World is told in less than five hundred words in the Book of Genesis. Lincoln's Gettysburg Address required less than ten minutes in its delivery. It will require only a few moments to run through the Secretary's report and summarize its contents.

The report is grouped under six headings: First, Historical, being a restatement of our fundamental aim, or in the words of the Congressman from Texas, "What are we here for?" and the means we have employed in attaining the end sought.

The second chapter deals with our activities during the past year, a reference to the subjects reported on by the standing and special committees, a list of organizations with which we have contact on matters of mutual concern, and a table showing the participation in committee-work by representatives of railways.

The third chapter relates to membership. We have now on the rolls 2,790 members. A table is given showing the classification of the membership, and a list of Railroad Presidents on the membership rolls; also, a geographical distribution of the membership. During the year we have sustained the loss of 34 honored and valued members.

The fourth chapter relates to the publications of the Association, and gives a list of the valuable papers contributed by members and others, which have added to the common fund of knowledge.

The fifth chapter covers finances, and shows that the receipts have exceeded the disbursements by a comfortable margin.

The sixth and last chapter deals with miscellaneous items, revisions of the General Rules under which we are now operating; list of A.R.E.A. members who have been honored by appointments as reporters to the International Railway Congress to be held in Spain and the World Engineering Congress to be held in Japan; reference to two oustanding monographs, one by Mr. Cushing, the other by Dr. von Schrenk, the transverse fissure detector car, and extent of use of A.R.E.A. recommended practice on the Illinois Central. Then follow financial statements and statistics. (Applause.)

REPORT OF THE SECRETARY

March 1, 1929.

To the Members:

The customary annual report on the Association's activities during the year, under the leadership of President W. D. Faucette, is presented under six headings:

(I) HISTORICAL
- a Purpose of the Association
- b General Policy
- c Success-Factors

(II) THE YEAR'S ACTIVITIES
- a Results of Committee-Work
- b Relations with Kindred Organizations
- c Personnel of Committees by Railways
- d Research Work

(III) MEMBERSHIP
- a Status of Membership March 1, 1929
- b Increase in Membership
- c Classification of Membership
- d Railway Executives on Membership Rolls
- e Geographical Distribution

(IV) PUBLICATIONS
- a General Notes
- b The "Manual"
- c Monographs

(V) FINANCES
- a Summary of Financial Statements

(VI) MISCELLANEOUS
- a Revision of General Rules
- b World Engineering Congress
- c Reporters for International Railway Congress
- d Transverse Fissure Detector Car
- e Use of Recommended Practice
- f Acknowledgment

Respectfully submitted,

E. H. Fritch

Secretary.

(I) HISTORICAL

The Thirtieth Annual Meeting of the American Railway Engineering Association is an occasion when it seems proper and fitting to restate our purpose and the general policy pursued in attaining that objective.

When the organization was established in March, 1899, it was dedicated to the proposition:

> **"The advancement of knowledge pertaining to the scientific and economic location, construction, maintenance and operation of railways."**

The Constitution of the organization provides that the following means be employed to accomplish this end:

(1) The study and investigation of problems pertaining to the objects of the Association through Standing and Special Committees.

(2) The publication of reports, papers and discussions.

(3) Meetings for the discussion of reports and papers, and for social intercourse.

(4) The maintenance of a reference library.

Upon this broad and sound foundation a structure has been reared in subsequent years that is conceded to be a model of effectiveness and of worth-while accomplishment.

(1) The Study and Investigation of Problems Through Committees

At the time of the formation of the Association, railway development had reached a point where the opinion or judgment of no one person was a sufficient guide for the profession. Hence, associations of men engaged in similar lines became necessary. The founders of the organization believed that in order to function properly, the best results would be obtained through the medium of standing or practically permanent committees, whose personnel would be composed of men specially qualified by training and experience to deal with specific problems.

One of the first acts of the Governing Board was to divide the Maintenance of Way and Structures Department into fourteen sub-divisions and to appoint a committee for each sub-division.

The next logical step was to draw up a program or outline of work for these fourteen committees. The problems peculiar to each sub-division were listed and a skeleton outline prepared, which has served as a guide to the present time in scheduling subjects for the various committees.

Developments in railway service made it necessary to create additional committees from time to time. The Association now has twenty-three standing and four special committees, with an approximate membership of over eight hundred.

(2) The Publication of Reports, Papers and Discussions

To provide for the dissemination of the information assembled by the several committees, a monthly Bulletin was established, which serves as a medium for the advance publication of committee reports, for publishing monographs contributed by members and others, announcements of interest to the membership relative to the general affairs of the Association, etc.

In addition, the Association publishes an annual volume of Proceedings, consisting of committee reports, monographs, and the verbal discussions at the annual meetings.

The "Manual of Recommended Practice" represents the net results of the Association's activities. This volume contains the recommendations for railway engineering and maintenance of way work approved by the membership at the annual meetings, and consists of principles of practice, definitions of terms, specifications for material and workmanship, and plans and designs.

(3) Meetings for the Discussion of Committee Reports, and for Social Intercourse

The annual gatherings of railway officials from all sections of the North American Continent during the conventions of the Association are devoted to the consideration and action on committee reports. The annual meetings may be likened to a "legislature," which passes laws for the government of a commonwealth—the "laws" we pass are the recommendations made by the respective committees as to what they consider good practice for railway engineering.

The personal contact with men from all portions of the Continent is of inestimable benefit to the individual member. It enlarges his acquaintanceship, and fosters a spirit of good-fellowship. The exchange of views and experiences on problems of mutual concern is another valuable feature of these meetings.

(4) The Maintenance of a Reference Library

It is the hope and expectation to eventually accumulate a reference library at the headquarters of the Association that will serve a constantly growing need.

The formula embodying the essential success-factors for the conduct of an enterprise, attributed to Sir Henry W. Thornton, Chairman and President of the Canadian National Railways, is an accurate description of the methods and practices of the American Railway Engineering Association during its entire history. The statement credited to Sir Henry is as follows:

> "Nothing so makes for results as organization, the avoidance of confusion. To do a thing, clear the mind; make a clean-cut picture of the thing to be done; build a formula that will fit the undertaking; organize your effort; shut out everything else and turn on the steam. Accomplishment is certain."

(II) THE YEAR'S ACTIVITIES

The principal activities of the past year are of course those of the Standing and Special Committees, whose reports appeared in Bulletins 310-315, inclusive.

Committee-work is the foundation of the Association's activities. How well and thoroughly the committees have performed their duty will be apparent by reference to the list of subjects dealt with during the year, given below.

The volume of Committee reports is very materially greater than in any previous year in the Association's history.

The wide range, comprehensiveness and timeliness of the subjects reported on are indicated in the following list:

CONTENTS OF COMMITTEE REPORTS—1928-9

Roadway .... **Bulletin 310**

Deformation of Roadbed
Permanent Roadbed
Conditions Which Should Govern the Use of Culverts
Specifications for Metal Culverts for Railway Use
Corrugated Metal Culvert Pipe for Railway Use
Specifications for Cast Iron Pipe
Best Methods of Preventing the Formation of Water Pockets Under the Ballast When Embankments Are Widened and/or Raised

Ballast .... **Bulletin 310**

Revision of Specifications for Washed Gravel Ballast
Comparative Merits of Ballast Materials
Cause and Effect of Pumping Joints in Railway Track
Shrinkage of Ballast Materials

Ties .... **Bulletin 311**

Anti-Splitting Devices
Adherence to Specifications
Best Practice for Switch Tie Renewals
Reports from Railways Making Tests on Substitute Ties
Inspection of "Brown" Ties on Pennsylvania Railroad
Electrical Conductivity of Concrete Ties
Grading Marks for Ties to Indicate Acceptance
Methods and Rules for Tie Acceptance Inspection
Traffic Unit for Comparing Cross-Tie Life
Data on Average Ties Renewed per Mile of Maintained Track
Proper Size Hole for Preboring

Rail .... **Bulletin 315**

Detection of Transverse Fissures in Track
Rail Failure Statistics for 1927
Transverse Fissure Statistics
Cause and Prevention of Rail Batter
Economic Value of Different Sizes of Rail
Reconditioning of Battered or Worn Rail Ends
Tests of Alloy Steel Rails

Track .... **Bulletin 314**

Curve Elevation
Plans of Switches, Frogs, Crossings and Slip Switches
Specifications for Foundations Under Railway Crossings
Reducing Rail Wear on Curves
Cause and Effect of Brine Drippings
Plans and Specifications for Track Tools
Specifications for Hickory Handles for Track Tools

Buildings .... **Bulletin 313**

Specifications for Buildings for Railway Purposes
Ornamental and Miscellaneous Metal Work
Brick Pavements and Floors
Sprinkler System
What Constitutes Appraisal of Fire Losses

Wooden Bridges and Trestles.......................... **Bulletin 314**

Revision of Grading Rules and Classification of Timber and Lumber for Railway Uses
Simplification of Grading Rules
Advantage of Establishing Supply Yards for Standard Trestle Timbers
Standardization and Simplification of Store Stock and Disposition of Material Reaching Obsolescence
Overhead Wooden Bridges

Masonry .... **Bulletin 313**

Principles of Design of Concrete, Plain and Reinforced
Second Report of the Joint Concrete Culvert Pipe Committee
Science and Art of Concrete Manufacture
General Practices for Waterproofing Railway Structures

Grade Crossings .... **Bulletin 312**

Revision of Manual—Highway Crossing Sign
Comparative Merits of Various Types of Grade Crossing Protection; Various Types and Location of Approach and Warning Signs for Grade Crossings; Practices in the Several States and Federal Requirements
Economic Aspects of Grade Crossing Protection in Lieu of Grade Crossing Separation
Use of Center Columns for Highway Grade Separations
Evolve a Formula Which Will Develop and Evaluate the Relative Benefits to the Public and Railways from:
(a) Grade Crossing Protection
(b) Elimination of Grade Crossings
(c) Reduction of Traffic on Highway Grade Crossings

Signals and Interlocking................................ **Bulletin 312**

Automatic Train Control
Development of Highway Crossing Protection
Increased Efficiency Secured in Railway Operation by Signal Indications in Lieu of Train Orders and Timetable Superiorities
Summary of Activities of Signal Section, A. R. A.

Records and Accounts................................. **Bulletin 313**

Changes or Revision in I. C. C. Classification of Accounts
Forms for Gathering the Necessary Data for Keeping Up to Date the Physical and Valuation Records of Railways
Forms for Handling the Interstate Commerce Commission's Requirements Under Order No. 15100—Depreciation Charges of Steam Railroad Companies
Statistical Requirements of the Accounting, Operating or Other Departments with Respect to Maintenance of Way and Structures

Rules and Organization................................ **Bulletin 311**

Rules for Employees Who Operate and Maintain Motor Cars
Rules for Maintenance of Buildings
Rules for Maintenance of Bridges
Rules for Maintenance of Other Terminal Structures
Study of Titles Below Rank of Division Engineer

Water Service and Sanitation.............................Bulletin 310

Pitting and Corrosion of Boiler Tubes and Sheets
Cost of Impurities in Locomotive Water
Protective Coatings for Interior of Steel Tanks and Underground Pipe Lines
Incrustation in Pipe Lines and Methods of Prevention
Use of Gravity and Pressure Filters
Fire Protection and Prevention at Water Stations
Design and Maintenance of Trackpans for Locomotive Supply
Methods Used in Obtaining Successful Wells in Fine Sand Formation
Water Columns, Their Advantages Over Tank Delivery
Handling Water for Drinking Purposes
Methods of Providing Drinking Water at Coach Yards
Railway Sanitation

Yards and Terminals.....................................Bulletin 312

Design of Coach Yards
Design and Operation of Facilities for Car-to-Car Transfer of L. C. L. Freight
Scales

Iron and Steel Structures...............................Bulletin 314

Specifications for Steel Highway Bridges—1929
Feasibility of Electric Welding of Connections in Steel Structures
Uses of Copper Bearing Steel for Structural Purposes
Effect of Dead Load on Impact from Moving Loads on Bridges
Rolling Tests of Plates
Punched and Reamed Work

Economics of Railway Location.........................Bulletin 313

Economics of Railway Location as Affected by the Introduction of Electric Locomotives
Essential Operating Data Required for Making Relative Comparisons of Values for Studies of Line and Grade Revisions to Meet Modern Operating Requirements
Discussion by C. P. Howard and W. L. R. Haines

Wood Preservation ....Bulletin 313

Definitions Used in Wood Preservation
Service Test Records of Treated Ties
Report on Piling Used for Marine Construction
Deterioration of Structures in Sea Water
Specifications for Treatment of Air-Seasoned Douglas Fir

Electricity ....Bulletin 312

Resolution—Edwin B. Katte
Inductive Co-Ordination
Water Power—Electrolysis
Overhead Transmission Line and Catenary Construction
Standardization of Insulating Tapes
Standardization of Insulators
Clearances for Third-Rail and Overhead Working Conductors
Specifications for Track and Third-Rail Bonds
Incandescent Lamp Schedules
Design of Indoor and Outdoor Substations
High Tension Cables
Application of Corrosion-Resisting Materials to Railroad Electrical Construction

Uniform General Contract Forms.......................Bulletin 311

Form of Agreement for Cost-Plus Percentage and Fixed Fee in Construction Contracts
Form of Agreement for Wire Line Crossings
Form of Application for Industry Track

Economics of Railway Operation .... **Bulletin 313**

Methods for Obtaining a More Intensive Use of Existing Railway Facilities
Methods for Determining Most Economical Train Lengths
Report of Improvements Made on a Heavy Traffic North and South Railway
Methods or Formulas for the Solution of Problems Relating to More Economical and Efficient Railway Operation
Flat Switching versus Hump Method
Study of Problems of Railway Operation as Affected by the Introduction of Motor Trucks and Bus Lines

Economics of Railway Labor .... **Bulletin 314**

Labor Saving Devices
Standardization of Parts and Accessories for Railway Maintenance Motor Cars
Equating Track Values for Labor Distribution
Economic Ratio of Supervision to Labor
Education and Training of the Individual Workman

Shops and Locomotive Terminals .... **Bulletin 311**

Locomotive Sanding Facilitles
Locomotive Repair Shops
Safe and Convenient Storage of Crude and Fuel Oil

Co-operative Relations with Universities .... **Bulletin 314**

Progress Report

Standardization .... **Bulletin 310**

Annual Review of Revision of Manual
Industrial-and-Association Mutual Affiliations in Standardization
American Standards Association
International Standardization
The Business of National Standardization
American Engineering and Industrial Standards
Extent of Use of A.R.E.A. Recommended Practices on Illinois Central Railroad
Industrial Standardization—Relationship of Bureau of Standards with American Standards Association

Stresses in Railroad Track .... **Bulletin 314**

Progress Report

Clearances .... **Bulletin 310**

Progress Report

Rivers and Harbors .... **Bulletin 311**

Rivers—Methods of Protecting River Banks Against Erosion
Construction of Levees and River Dikes for Flood Protection
Harbors—Protection and Maintenance of Levees During Flood

RELATIONS WITH KINDRED ORGANIZATIONS

Co-operation with organizations has been continued on matters of mutual interest. The following is a summary of such collaboration:

International Committee on Weights and Measures

The U.S. Bureau of Standards invited the A.R.E.A. to be represented at a conference to discuss the question of an international agreement on temperature for intercomparison of industrial standards. W. C. Cushing, Engineer of Standards, The Pennsylvania Railroad, was designated by President Faucette to serve in that capacity. The Bureau announces that as a result of its investigation, it has recommended that 68 degrees Fahr. (20 degrees C.) as the best standard temperature for use in connection with industrial standards, gage blocks, etc.

War Memorial at Louvain (Belgium) University

Dr. W. K. Hatt, Professor of Civil Engineering Purdue University, was delegated by President Faucette to represent the A.R.E.A. at the dedication of the war memorial at the University of Louvain, in memory of American Engineers who lost their lives in the World War.

Advisory Committee on Tests of a Reinforced Concrete Bridge

President Faucette designated J. B. Hunley, Engineer of Bridges and Structures, Cleveland, Cincinnati, Chicago & St. Louis Railway, as member of an advisory committee for tests on a reinforced concrete bridge over the Yadkin River in North Carolina. Mr. Hunley's report on the results of the tests will appear in abstract form in a future Bulletin.

Translation Into Spanish of Specifications for Concrete

The report of the Joint Committee on Specifications for Concrete and Reinforced Concrete, adopted by the A.R.E.A. at the annual meeting in 1927, has been translated into the Spanish language and published in "Ingenieria," the official monthly publication of the College of Engineering, National University of Mexico.

Tests on Bearing Values of Large Rollers

This study has been continued at the University of Illinois, under the auspices of the Committee on Iron and Steel Structures. The experiments are being made under direction of Prof. W. M. Wilson, member of the Committee. The tests are being financed principally by the American Railway Association, and in part by the Scherzer Rolling Bascule Bridge Company. A comprehensive report on the tests appears in Bulletin 314, for February, 1929.

Boiler Feed Water Studies

The Committee on Water Service and Sanitation is now assembling data in support of the request for an appropriation by railways to conduct tests on boiler feed water. The National Electric Light Association has indicated its willingness to make a very substantial contribution to the proposed fund.

Appalachian Power Conference

The invitation extended to the Association to be represented at the above-named conference was accepted, and W. L. Morse, Special Engineer, New York Central Railroad; Reuben Hayes, Engineer Maintenance of Way, Southern Railway, and L. L. Beall, Chief Engineer, Atlantic, Birmingham & Coast Railway, were designated by President Faucette to represent the Association. The conference was held at Chattanooga, Tenn., October 8th to 10th.

National Fuels Meeting

This meeting was attended by Geo. H. Tinker, Bridge Engineer, New York, Chicago & St. Louis Railway, and H. W. Fenno, Engineer Maintenance of Way, New York Central Railroad (Lines West), as delegates from the A.R.E.A. The meeting was held at Cleveland, September 17th to 20th.

Joint Committee on Railway Sanitation

The designation of the Joint Committee on Drinking Water Supplies has been changed to the above form during the year, and its scope enlarged to cover the subjects implied in the title.

PERSONNEL OF COMMITTEES BY RAILWAYS—1928

Railroads	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Grade Crossings	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service and Sanitation	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Contract Forms	Economics of Ry. Operation	Economics of Ry. Labor	Shops and Locomotive Terminals	Cooperative Relations with Universities	Stresses in Track	Standardization	Clearances	Rivers and Harbors	Total
Atlantic Coast Line				1							1								1					1				4
Atchison, Topeka & Santa Fe	2	2	2	1	1	1		1	1	1		2	1	1	1	1	1			1	1	1			1	1		24
Gulf, Colorado & Santa Fe																					1	1						2
Atlanta & West Point																					1							1
Baltimore & Ohio	1	2	1	2	1	2		1	3		1	2	2	1	1	1	1	2		2	3	1		2	2			33
B. & O. Chicago Terminal			1						1																			2
Bessemer & Lake Erie																1				2					1			4
Boston & Maine	1			1				1				1		1			1	1							1		1	9
Canadian National	1	1	1	1	1		1	1		1	1	1	1	1	1		1	1	1	3		1			2			22
Grand Trunk Western								1						1					1		1	1						5
Canadian Pacific	1	2		2	1	1		1	1			1	1	1	1		1			1		1	1		1	1		19
Central of Georgia			1			1	1												1								1	5
Central of New Jersey								1				2						2	1	1								7
Chesapeake & Ohio	1	3	2	1	1	1	1	1	1		3	1	3			2				2	3	2	1					29
Chicago & Eastern Illinois									1						1							1						3
Chicago & Northwestern	1				1				1	1	1	1	1		1		1	1		1		1						12
Chicago, St. Paul, Minneapolis & Omaha																			1									1
Chicago & Western Indiana		1			1			1	1		1	1		1								1						8
Chicago, Burlington & Quincy		1	1	2	3	1	1	1	2		1	1	1		1	1	1			1		1						20
Chicago Great Western																1												1
Chicago, Rock Island & Pacific	1	1	1	2	2	1		1	1	1	2	1	2	2	1		2			2	1	1	2	1	3	2		33
Chicago, Indianapolis & Louisville	1									1																		2
Chicago, Milwaukee, St. Paul & Pacific		1	1	1			1	2			1						1	1		2	1	2						14
Chicago Rapid Transit				1																								1
Chicago, West Pullman & Southern												1																1
Cleveland Union Terminal																		1										1
Clinchfield																			1									1
Copper Range																1												1
Delaware, Lackawanna & Western	1		1	1	1	1	2	1					1					1		1				1	1			13
Delaware & Hudson														1														1
Denver & Rio Grande Western							1																					1
Duluth & Iron Range	1																											1
Duluth, Missabe & Northern							1																		1	1	1	4
Elgin, Joliet & Eastern					1						1			1								1						4
Erie					1	1			1				1						1		1			1				7
Florida East Coast	1	1			1	1	1	1			1	1			1												1	10
Fort Worth & Denver City							1																					1
Great Northern			1					1					1				1											4

Hocking Valley							1	1								1												3
Illinois Central	1	1	2	2	2	1	1	1	2	2	2	2	2	2		2	1	3	1	2	1		1		3	1	2	40
Jacksonville Terminal														1														1
Johnstown & Stony Creek					1																							1
Kansas City Southern	1										1		1		1						1		1		1			7
Kansas City Terminal										1				1														2
Lake Superior & Ishpeming			1																								1	2
Lehigh Valley				1				1				1													1	1		5
Long Island																		3										3
Louisville & Nashville	1		1	1	1		1						1	1														7
Maine Central						1																						1
Minneapolis & St. Louis	1																											1
Minnesota & International																						1						1
Missouri Pacific	2	2	1	1	1	1	3	2	1	2	2	1	2			2			1		2	1	1	2	1		2	33
Gulf Coast Lines			1																		1							2
Inter. Great Northern																					1	1						2
Missouri-Kansas-Texas						1			1		1		2		1	1					1	1						9
Mobile & Ohio							1																					1
Montana, Wyoming & Southern																1												1
Nashville, Chatt. & St. Louis	1			1																	1							3
New York Central Lines				1		1					1		1			1		1						1				7
Boston & Albany						1													1						1			3
Big Four			1				1				1				2	1					1	1						8
Indiana Harbor Belt									1																			1
E. I. & T. H.																			1									1
Michigan Central					2		1	1	1	1				1				1			1							9
New York Central R. R.	1	2	1	1		1		1	3	2		2	1		3		1	5		1	1	1			1	2	1	31
Peoria & Eastern	1				2															1								4
New York, Chicago & St. Louis			1		1										1				1									4
N. Y., New Haven & Hartford			1	1		2			1		1			2	1			2	1	3					1			16
Norfolk Southern				1															1									2
Northern Pacific			2			1	1	1	2				2			1	1				1							12
Pennsylvania	1		1	3	3			2	3	2	1	1	2	3	1	1	1	1		2			1	1	4	3		37
Norfolk & Western	1			1					1					1	1			1				1	1				1	9
Peoria & Pekin Union		1																							1			2
Missouri & No. Ark																					1							1
Northwestern Pacific																1												1
New York, Ontario & Western																					1							1
Pere Marquette	1							1													1							3
Reading	1	1		1	1						1	1	1		1	1	1	2										12
Richmond, Fredericksburg & Potomac		1												1						1								3
St. Louis-San Francisco	1						1						1								1						1	5
St. Louis Southwestern		1											1										1					3
Seaboard Air Line					1	1										1			2	1			1					6
Soo Line																	1											1
Southern	2				1		1			1			1		1												1	8
Southern Pacific	1	1	1	2	1		1			1			1			1	3	1				2					1	17
Temiskaming & Nor. Ont			1																									1
Term. R. R. Assn. St. Louis					1							1																2
Texas & Pacific													1														1	2
Toronto Terminals								1						1											1			3
Union Pacific				3					1	1	1		1		1						1							9
United Railway Elec. Co			1																									1
Wabash	1		1			1	1	1					1		1													7
Waterloo, Cedar Falls & Nor									1																			1
Wheeling & Lake Erie		1																										1
Western Maryland														1														1
Western Pacific			1																									1
Non-Railroad Members	3	5			8	3	4	8	2	1	3	3	3	11	10	9	6	2	4	6	1	2	7	9	1		11	12
TOTALS	34	31	31	36	41	26	29	37	34	19	29	28	41	38	34	32	26	32	21	36	31	26	18	19	27	12	16	783

Committee on Automatic Train Control, A.R.A.

Two changes were made in the representation of the Engineering Division on this Joint Committee during the year—the death of Edwin B. Katte created a vacancy, which was filled by the appointment of John V. Neubert, Chief Engineer Maintenance of Way, New York Central Railroad; H. E. Stevens, Vice-President, Northern Pacific Railway, resigned, and Bernard Blum, Chief Engineer of the same company, was appointed to fill this vacancy.

American Committee on Electrolysis

The Committee on Electricity is maintaining contact with this organization through three representatives—Martin Schreiber, Chairman; W. M. Vandersluis, Vice-Chairman, and H. A. Currie.

Joint Committee on Concrete and Reinforced Concrete

The Masonry Committee is represented on this Joint Committee by T. L. D. Hadwen, F. E. Schall, C. C. Westfall and J. J. Yates.

Joint Committee on Culvert Pipe

Two members who have heretofore represented the Masonry Committee on this joint body died during the year—A. F. Robinson, Bridge Engineer of the Atchison, Topeka & Santa Fe, and Job Tuthill, Assistant Chief Engineer, Pere Marquette Railway. G. A. Haggander, Bridge Engineer, Chicago, Burlington & Quincy, succeeded the late Mr. Robinson. A report made by the Joint Committee is incorporated in the report of the Masonry Committee (Bulletin 313, January, 1929).

Marine Piling Investigation

The Association's representatives on this investigation, Dr. Hermann von Schrenk, Chairman; Col. Wm. G. Atwood, C. S. Burt, G. F. Eberly, Andrew Gibson, W. H. Kirkbride, have continued co-operation with the Chemical Warfare Service in the study of marine piling. A progress report is included in the current report of the Committee on Wood Preservation (Bulletin 313, January, 1929).

American Standards Association

The American Engineering Standards Committee has changed its title to "American Standards Association" and adopted a new Constitution. The report of the Committee on Standardization, Bulletin 310, October, 1928, contains the revised Constitution of the American Standards Association. W. C. Cushing, Engineer of Standards, The Pennsylvania Railroad, represents the Engineering Division in that organization.

Joint Committee on Metric System of Weights and Measures

President W. D. Faucette is Chairman of this joint committee, appointed by the American Railway Association, for the purpose of keeping in touch with developments in the efforts made by certain interests to make the use of the metric system of weights and measures compulsory in this country. John R. Leighty, W. P. Wiltsee, and M. J. J. Harrison are associated with Mr. Faucette on this joint committee.

Rail Manufacturers' Technical Committee

Co-operation has been continued with the Technical Committee of Rail Manufacturers, through the Committee on Rail, in studying the principal causes of transverse fissure in steel rails.

Manganese Track Society

The collaboration of the Track Committee and the Manganese Track Society has been continued and has proven of mutual benefit. As a result of this co-operation, nearly 200 track work plans have been formulated and approved by the Association.

(III) MEMBERSHIP

The table below is a record of the additions, deaths, resignations, and dropped in the membership rolls during the year:

Membership as of March 1, 1928			2,607
Additions during the year		325	
Losses by death	34		
Resignations	36		
Dropped from rolls	72	142	
Net gain		183	183
Total membership as of March 1, 1929			2,790

Increase in Membership

Special efforts were made in the past year to bring the membership number up to "3000" to correspond to the thirtieth annual meeting, but unfortunately this expectation was not quite realized.

Through the efforts of President Faucette, and the hearty co-operation of individual members, it is gratifying to note a substantial increase over the preceding year.

The Association is also indebted to Mr. C. E. Johnston, President, Kansas City Southern Railway, for securing the affiliation of approximately thirty-five members, principally Railway Presidents, Vice-Presidents, General Managers, etc.

Classification of Membership

The following table is a departmental classification of the membership:

General Officers Includes Chairmen of Boards, Presidents, Directors, Vice-Presidents, Assistants to President, General Managers, Assistant General Managers	203
Conducting Transportation Officers Includes General and Assistant General Superintendents, Division Superintendents, Trainmasters	112
Maintenance of Way and Structures Officers Includes Chief Engineers, Chief Engineers of Maintenance of Way, Engineers Maintenance of Way, Bridge Engineers, Division Engineers, Signal Engineers, Assistant Engineers, etc.	1846
Maintenance of Equipment Officers Includes General Superintendents of Motive Power, and other Mechanical Department Officers	17
Traffic Officers	5
Accounting Officers	21
Purchasing and Stores Department Officers	4
Professors in Colleges	68
Miscellaneous Includes Consulting and Civil Engineers, Engineers of Industrial Corporations, Government and Municipal Engineers, etc.	514
Total	2790

Deceased Members

It is with deep regret that we record the loss of the following valued members since the last annual meeting:

H. H. ALTHOUSE,
Consulting Engineer, Reading, Pa.

*JOHN B. BERRY,
Consulting Engineer, Omaha, Neb.

C. G. BURNHAM,
Executive Vice-President, Chicago, Burlington & Quincy Railroad

J. M. COWSERT,
Supervisor, Water Department, Missouri Pacific Railroad.

*GARRETT DAVIS,
Division Engineer (retired), Chicago, Rock Island & Pacific Railway

*PAUL DIDIER,
Principal Assistant Engineer, Baltimore & Ohio Railroad

HOWARD ELLIOTT,
Chairman of Board, Northern Pacific Railway

W. J. GOODING,
Division Engineer, Seaboard Air Line Railway

C. S. HENNING,
Construction Engineer, Southern Pacific Company

G. H. HICKS,
Chief Engineer, Northwestern Pacific Railroad

A. P. HIMES,
Assistant Engineer, New York, Chicago & St. Louis Railway

J. M. HOAR,
Assistant Engineer, Illinois Central Railroad

C. A. HORNECKER,
Supervisor Bridges and Buildings, Missouri Pacific Railroad

R. H. HOWARD,
Chief Engineer, Wabash Railway

RICHARD L. HUMPHREY,
Consulting Engineer, Philadelphia, Pa.

D. B. JOHNSTON,
Division Engineer, Pennsylvania Railroad

EDWIN B. KATTE,
Chief Engineer, Electric Traction, New York Central Railroad

*Charter Member.

Deceased Members

*Howard G. Kelley *(Past-President)*,
Former President, Grand Trunk Railway System

J. A. Killian,
Engineer Maintenance of Way, Southern Railway System

W. P. Kritzer,
Resident Engineer, Chesapeake & Ohio Railway

C. M. Larsen,
Chief Engineer, Wisconsin Railroad Commission

F. D. Nauman,
Engineer Maintenance of Way, Oregon Short Line Railroad

R. S. Parsons,
Chief Engineer, Erie Railroad

E. J. Pearson,
President, New York, New Haven & Hartford Railroad

J. H. Reagan,
Superintendent Track, Grand Trunk Western Railway

Albert F. Robinson,
Bridge Engineer, Atchison, Topeka & Santa Fe Railway System

L. O. Sloggett,
Field Engineer, Terminal Improvements, Illinois Central Railroad

W. T. Spencer,
Superintendent, New York, New Haven & Hartford Railroad

J. A. Spielmann,
Assistant General Superintendent, Baltimore and Ohio Railroad

J. E. Turk,
Retired General Superintendent, Reading Company

F. A. Turner,
Assistant Engineer, Texas & Pacific Railway

Job Tuthill,
Assistant Chief Engineer, Pere Marquette Railway

B. A. Wait,
Instrumentman, Chicago, Rock Island & Pacific Railway

J. H. Waterman,
Representative, Curtin-Howe Corporation (formerly Superintendent Timber Preservation, Chicago, Burlington & Quincy Railroad).

*Charter Member.

Railway Executives on Membership Rolls

For the past several years, report has annually been made of railways whose Executives were affiliated with the Association.

The following table gives the roads and names of Presidents holding membership in the Association:

Akron, Canton & Youngstown	H. B. Stewart, President
Atchison, Topeka & Santa Fe	W. B. Storey, President
Atlanta, Birmingham & Coast	B. L. Bugg, President
Atlantic Coast Line	G. B. Elliott, President
Augusta & Summerville	W. M. Robinson, President
Baltimore & Ohio	Daniel Willard, President
Bangor & Aroostook	Percy R. Todd, President
Boston & Maine	George Hannauer, President
Buffalo, Rochester & Pittsburgh	W. T. Noonan, President
Canadian National	Sir Henry W. Thornton, Chairman and President
Canadian Pacific	E. W. Beatty, Chairman and President
Central of Georgia	A. E. Clift, President
Central of New Jersey	W. G. Besler, Chairman of Board R. B. White, President
Chesapeake & Ohio	W. J. Harahan, President
Chicago, Burlington & Quincy	F. E. Williamson, President
Chicago Great Western	S. M. Felton, Chairman of Board N. L. Howard, President
Chicago, Rock Island & Pacific	J. E. Gorman, President
Chicago & Eastern Illinois	T. C. Powell, President
Chicago & Northwestern	F. W. Sargent, President
Colorado & Wyoming	J. F. Welborn, President
Chicago & Western Indiana	E. H. Lee, President
Delaware, Lackawanna & Western	J. M. Davis, President
Denver & Rio Grande Western	J. S. Pyeatt, President
Duluth, Missabe & Northern	W. A. McGonagle, President
Elgin, Joliet & Eastern	A. F. Banks, President
Eureka & Nevada	J. H. Sherburne, President
Great Northern	Ralph Budd, President
Huntingdon & Broad Top Mountain	J. Bancroft, President
Illinois Central	C. H. Markham, Chairman of Board L. A. Downs, President
International Railways of Central America	Fred Lavis, President
Jacksonville Terminal	J. L. Wilkes, President
Kansas City Southern	C. E. Johnston, President
Lehigh Valley	E. E. Loomis, President
Louisville & Nashville	W. R. Cole, President
Minneapolis, St. Paul & Sault Ste. Marie	C. T. Jaffray, President
Montana, Wyoming & Southern	M. A. Zook, President
Missouri Pacific	L. W. Baldwin, President
Missouri-Kansas-Texas	C. Haile, President
New York Central Lines	P. E. Crowley, President
New York, New Haven & Hartford	J. J. Pelley, President
Nickel Plate Road	W. L. Ross, President
Northern Pacific	Charles Donnelly, President
Norfolk & Western	A. C. Needles, President
Pennsylvania System	W. W. Atterbury, President
Peoria & Pekin Union	V. V. Boatner, President
Pere Marquette	F. H. Alfred, President
Reading	A. T. Dice, President
Richmond, Fredericksburg & Potomac	E. Hunton, Jr., President
St. Louis-San Francisco	J. M. Kurn, President
St. Louis Southwestern	Daniel Upthegrove, President
Seaboard Air Line	L. R. Powell, Jr., President
Southern Pacific	Hale Holden, Chairman Executive Committee Paul Shoup, President
Southern Railway System	Fairfax Harrison, President
Tennessee Central	H. W. Stanley, President
Terminal Railroad Assn. of St. Louis	Henry Miller, President
Toledo Terminal	A. B. Newell, President
Union Pacific	Carl R. Gray, President
Wabash	J. E. Taussig, President
Western Maryland	M. C. Byers, Chairman of Board and President
Western Pacific	T. M. Schumacher, Chairman Executive Committee

Representing 215,687 miles of railroad.

GEOGRAPHICAL DISTRIBUTION OF MEMBERSHIP

United States and Possessions

Alabama	6	Nebraska	38
Arizona	4	New Jersey	48
Arkansas	42	New Hampshire	6
California	76	New Mexico	2
Colorado	17	New York	257
Connecticut	28	North Carolina	24
Delaware	1	North Dakota	4
District of Columbia	31	Ohio	153
Florida	27	Oklahoma	21
Georgia	60	Oregon	8
Hawaii	1	Pennsylvania	197
Idaho	8	Philippine Islands	2
Illinois	369	Porto Rico	2
Indiana	48	Rhode Island	5
Iowa	26	South Carolina	2
Kansas	60	Texas	113
Kentucky	46	Tennessee	29
Louisiana	27	Utah	8
Maine	11	Vermont	10
Maryland	66	Virginia	100
Massachusetts	65	Washington	27
Michigan	59	West Virginia	30
Minnesota	71	Wisconsin	15
Mississippi	14	Wyoming	4
Missouri	235		
Montana	12		2515

Other Countries

Canada	153	France	3
Japan	30	Manchuria	2
South America	14	Siam	2
China	11	Czecho-Slovakia	1
India	6	Ireland	1
Mexico	11	Scotland	1
Cuba	9	New Zealand	1
Australia	6	Poland	1
Africa	3	Spanish Honduras	1
England	5	Sudan	1
Costa Rica	2	Sweden	1
Korea	2	Jamaica	1
Egypt	2	Malay States	1
Union Socialistic Soviet Republic	2		
Central America	2		275

(IV) PUBLICATIONS

General Notes

By means of its publications—the monthly Bulletin, the annual volume of the Proceedings, and the Manual of Recommended Practice—the Association disseminates the results of committee-work; the monographs presented by members and others; and the verbal and written discussions.

The demand for these publications is continually increasing, indicating a growing appreciation of their value to railway officers in practically every branch of the service.

The "Manual"

It was contemplated to issue a revised Manual during the past year. On request of several Committees, the Board of Direction has postponed the issuance of this volume to afford the respective Committees more time in which to reconcile certain discrepancies, eliminate duplication, and otherwise perfect the material to be contained in the Manual.

The revised Manual will be issued as promptly as practicable after the annual meeting.

Monographs

The contributions made by individual members and others in the form of papers during the year have been of surpassing interest and of permanent value. A list of these monographs follows:

"Mechanical Wear of Ties."—By Dr. Hermann von Schrenk (Bulletin 306, June, 1928).

"Tests on Swift Island Bridge."—By J. B. Hunley, Engineer Bridges and Structures, Cleveland, Cincinnati, Chicago & St. Louis Railway (Bulletin 307, July, 1928).

"Combing the Railroad."—By Alexander Whilldin, Clearance Engineer, The Pennsylvania Railroad (Bulletin 307, July, 1928).

"Why Real Wages Have Increased 35 Per Cent in 14 Years."—By Dr. H. P. Gillette, Editor, *Engineering and Contracting* (Bulletin 307, July, 1928).

"New England Flood of 1927."—By Special Committee of Chief Engineers (Bulletin 308, August, 1928).

"Past-Presidents' Bulletin."—A Symposium contributed by twelve Past-Presidents on various topics (Bulletin 309, September, 1928).

"Rail and Wheel."—By W. C. Cushing, Engineer of Standards, The Pennsylvania Railroad (Bulletin 315, March, 1929).

"Translating the Physical Characteristics of a Railway Line Into Straight and Level Miles and Ton-Mile Costs."—By J. L. Campbell, Chief Engineer, Northwestern Pacific Railroad (Bulletin 315, March, 1929).

"Discussion on Depreciation in Railroad Properties."—By J. P. Snow, Consulting Engineer (Bulletin 315, March, 1929).

"The Southern Pacific Company's Twelve-Million-Dollar Bridge Across Suisun Bay."—By C. R. Harding, Engineer of Standards, Southern Pacific Company (Bulletin 315, March, 1929).

Note.—Above listed papers are not reprinted in this Volume in order to obviate printing the Proceedings in two volumes. Members are therefore requested to preserve the Bulletins containing these valuable monographs.

(V) FINANCES

The Financial Statement, appended to this report, gives in detail the receipts, and disbursements. It will be noted that the receipts exceeded the expenditures by $2,321.21.

The expenditures for printing will be unusually large during the current year. A new Manual is to be issued, and also a General Index, in addition to the voluminous Bulletins and Proceedings. It will therefore be necessary to devise ways and means for increasing our revenues to meet these obligations.

(VI) MISCELLANEOUS

Revision of "General Rules for the Preparation, Publication and Consideration of Committee Reports"

On the recommendation of the Committee on Outline of Work, the Board of Direction has approved a revision of the above "General Rules" in the following particulars:

Rule 4. Change to read: "As soon as practicable after January 1st of each year, the Board of Direction will assign to each Committee the important questions which, in its judgment, should preferably be considered during the current year, etc."

Rule 9. Change date for filing Committee reports from November 30th to *November 1st.*

Carrying out the intent of the above revisions, the Board Committees on Outline of Work and on Personnel promulgated the program for the ensuing year and the personnel of the standing and special committees on January 1st. The early announcement of subjects to be studied and reported on and committee appointments will enable committee-work to be carried on during the winter months and make it possible to complete the reports in time to be issued to the membership well in advance of the annual meetings.

Robert H. Ford and John V. Neubert, respectively, Chairmen of the Board Committees on Outline of Work and Personnel of Committees, deserve credit for this distinct advance in committee-work.

"Reporters" for International Railway Congress in Spain

The following members of the A.R.E.A. have been appointed "Reporters" for the International Railway Congress, to be held in Madrid, Spain, in 1930:

F. B. Freeman, Chief Engineer, New York Central Railroad.
R. B. Abbott, Assistant General Superintendent, Reading Company.
P. G. Lang, Jr., Engineer of Bridges, Baltimore & Ohio Railroad.
J. V. B. Duer, Electrical Engineer, Pennsylvania Railroad.
G. H. Dryden, Signal Engineer, Baltimore & Ohio Railroad.
C. C. Cook, Maintenance Engineer, Baltimore & Ohio Railroad.
L. C. Fritch, Vice-President, Chicago, Rock Island & Pacific Railway.
C. W. Lloyd-Jones, General Manager, The Nizam's State Railways.

World Engineering Congress in Tokio, Japan, October, 1929

The Kogakkai (Engineering Society of Japan) announces a World Engineering Congress, to be held in Tokio, Japan, in October, 1929.

The object of the World Engineering Congress is to effect an international exchange of the latest knowledge of the sciences and practices of Engineering and to bring together the leaders in research, education and business who are directing the trend of Engineering activities, thereby initiating and promoting international co-operation and understanding of Engineers of the world, so essential to the advancement of the welfare of mankind.

The Patron of the Congress is His Imperial Highness Prince Yasuhito of Chichibu; Honorary President, His Excellency, the Prime Minister of Japan; Honorary Vice-President, His Excellency, the Minister of the Department of Commerce and Industry, Viscount Eiichi Shibusawa.

An invitation has been extended to the American Railway Engineering Association to participate in the Congress and to delegate a representative. The Board of Direction has accepted the invitation, and appointed Secretary E. H. Fritch to represent the Association at the Congress.

The following is a reproduction of a petition in the Japanese language, joined in by thirty-one members of the Association residing in Japan, addressed to the Board of Direction. A translation is given below.

拝啓 陳者明一九二九年秋
東京に於て開催せらるべき世界
工学大会に貴協会を代表しイー・
エイチ・フリッチ氏を御差遣相成
度右御招待旁々此段得貴
意候 敬具

一九二八年六月一日
黒河内四郎

米国イリノイ州シカゴ市南デアボン街四三一
米国鉄道工学協会御中

(Translation)

JAPANESE GOVERNMENT RAILWAYS

Tokio, June 1, 1928.

The Board of Direction of the American Railway Engineering Assn.,
431 South Dearborn Street, Chicago, Illinois, U. S. A.

Gentlemen:

I hope that you will kindly send Mr. E. H. Fritch to my country as a delegate of your association to the World Engineering Congress to be held in Tokio in the fall of next year (1929).

Thanking you in advance for your kind consideration on this matter, I am,

(Signed) S. KUROKOCHI,
(Chief Engineer Maintenance of Way, J. G. R.)

"The Rail and Wheel"

One of the outstanding contributions to the Bulletin of the Association is the monograph presented by W. C. Cushing, Engineer of Standards, The Pennsylvania Railroad, issued in Bulletin 315, for March, 1929.

This monograph is a critical survey of the physical requirements for steel rails, and includes a review of mathematical and technical analyses applied to rail design, and the genesis of the transverse fissure.

The Association is deeply indebted to Mr. Cushing for this classic.

"Mechanical Wear of Cross-Ties"

The Bulletin (No. 306, June, 1928) containing this monograph by Dr. Hermann von Schrenk, Consulting Timber Engineer, has created favorable comment among Engineers in this country and abroad. The Board of Direction, on behalf of the Association, has extended a vote of thanks to Dr. von Schrenk for this noteworthy contribution to the publications of the Association.

New England Flood of 1927

In view of the disastrous flood in the New England States in 1927, the Board of Direction deemed it desirable to record the part played by railroads in restoring their properties to use and in relieving the communities affected by this calamity. President Faucette therefore appointed a Special Committee, consisting of Chief Engineers of roads operating in the New England territory, to prepare a history of the flood for publication in the Bulletin. The report made by this Special Committee appeared in Bulletin 308, for August, 1928.

Transverse Fissure Detector Car

This device, intended to discover the type of rail failure termed "transverse fissure," and developed under the auspices of the Rail Committee, was placed in service in November last. Since that time it has been in operation on the tracks of the New York Central, Lehigh Valley, Reading, Pennsylvania, Baltimore and Ohio, Rock Island, Kansas City Southern, and St. Louis-San Francisco Railways.

A report and description of the detector car is included in the report of the Rail Committee in Bulletin 315 for March, 1929.

Extent of Use of A.R.E.A. "Recommended Practice"

A. F. Blaess, Chief Engineer, Illinois Central System, has made a survey to ascertain to what extent the A.R.E.A. recommended practices have been applied in the Engineering Department of that great railroad. The result of this study has been included in the report of the Committee on Standardization, Bulletin 310, October, 1928, pages 106-117.

Similar surveys if made on other roads would undoubtedly show equally gratifying results.

Acknowledgment

The loyal and efficient services of the office staff during the year is hereby gratefully acknowledged.

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1928

Balance on hand January 1, 1928		$54,005.45

RECEIPTS

Membership Account		
Entrance Fees	$ 3,310.00	
Dues	26,031.16	
Binding Proceedings and Manual	1,988.83	
Badges	27.00	
Sales of Publications		
Proceedings	4,395.88	
Bulletins	1,933.66	
Manual	368.89	
Specifications	793.26	
Leaflets	524.88	
Advertising		
Publications	2,364.60	
Interest Account		
Investments	2,111.25	
Bank Balance	218.70	
Annual Meeting		
Sale of Dinner Tickets	5,045.00	
Miscellaneous	25.35	
American Railway Association		
Rail Investigations	8,946.94	
Total	$58,085.40	

DISBURSEMENTS

Salaries	$10,162.42	
Proceedings	7,392.51	
Bulletins	16,091.57	
Manual	25.00	
Stationery and Printing	1,924.10	
Rents, Light, etc	845.00	
Supplies	774.83	
Expressage	772.35	
Postage	1,163.85	
Exchange	166.05	
Committee Expenses	93.40	
Officers' Expenses	548.86	
Annual Meeting	6,611.54	
Refund Dues, etc	55.00	
Audit	200.00	
Miscellaneous	665.39	
American Railway Assn.—Rail Investigations	8,272.32	
Total	$55,764.19	
Excess of Receipts over Disbursements		$ 2,321.21
Balance on hand December 31, 1928		$56,326.66
Consisting of:		
Bonds at Cost	$40,785.89	
Cash in National Bank of Republic	15,515.77	
Petty Cash Fund	25.00	
	$56,326.66	

STRESSES IN TRACK FUND

Balance on hand January 1, 1928		$ 1,904.87
Received from interest during 1928		53.70
Total		$ 1,958.57
Paid out on Audited Vouchers during 1928		187.74
Balance of fund on hand December 31, 1928		$ 1,770.83

REPORT OF THE TREASURER

Balance on hand January 1, 1928		$54,005.45
Receipts during 1928	$58,085.40	
Paid out on Audited Vouchers 1928	55,764.19	
Excess of Receipts over Disbursements		2,321.21
Balance on hand December 31, 1928		$56,326.66
Consisting of:		
Bonds at Cost	$40,785.89	
Cash in National Bank of Republic	15,515.77	
Petty Cash Fund	25.00	
	$56,326.66	

STRESSES IN TRACK FUND

Balance on hand January 1, 1928		$ 1,904.87
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Total		$ 1,958.57
Paid out on Audited Vouchers during 1928		187.74
Balance of fund on hand December 31, 1928		$ 1,770.83

The Securities listed above are in a safety deposit box of the National Bank of the Republic, Chicago, Illinois.

Respectfully submitted,

F. J. Stimson,

Treasurer.

I have made an audit of the accounts of the American Railway Engineering Association for the year ending December 31, 1928, and find them to be in accordance with the foregoing financial statements.

Charles Campbell,

Auditor.

GENERAL BALANCE SHEET

December 31, 1928

	1928	1927
Assets		
Due from Members	$ 4,884.30	$ 3,773.78
Due from Sale of Publications	536.94	1,233.96
Due from Advertising	2,910.00	3,275.00
Due from A.R.A.—Rail Investigations	804.63	1,487.25
Furniture and Fixtures	997.40	997.40
Gold Badges	20.00	45.00
Publications on Hand (Estimated)	6,000.00	6,000.00
Manual	300.00	500.00
General Index	3,269.89	3,269.89
Extensometers	500.00	500.00
Investments (Cost)	40,785.89	43,285.89
Interest on Investments (Accrued)	257.20	288.19
Cash in National Bank of the Republic	15,515.77	10,694.56
Petty Cash Fund	25.00	25.00
Total	$76,807.02	$75,375.92
Liabilities		
Members' Dues Paid in Advance	$ 7,548.27	$ 7,573.00
Impact Test Fund on Electrified Railways	285.46	285.46
Due for Printing Bulletins, etc.	2,804.04	
Surplus	66,169.25	67,517.46
Total	$76,807.02	$75,375.92

The President:—You have heard the reports of the Secretary and Treasurer. What is your pleasure?

Mr. G. W. Kittredge (Past-President):—I move that the reports be received and approved.

The President:—Do I hear a second?

(The motion was regularly seconded, was put to a vote and carried.)

The President:—Before I excuse the Board of Direction, I should be glad to know if any of them have anything they wish to say. If not, the Board of Direction is excused with the thanks of the Association for the work they have performed. (Applause.)

The privileges of the floor are extended to the various officials of railroads and allied companies, Professors and Deans of Colleges and Universities, and to others in engineering work, whom we desire to participate in these sessions.

I wish at this moment to take just a minute of your time away from the regular order and to read quickly some messages we have received from those in whom we are interested.

I just received during the time that Mr. Coolidge was President, and on the fourth of the month, a communication through his Secretary, Mr. Sanders. Briefly he states that "President Coolidge extends his greetings and best wishes to the organization through you."

I am also pleased to read a letter from Mr. Charles E. Mitchell, President of the National City Bank of New York City. I had a conversation with Mr. Mitchell some time ago, and he said he was going to write a brief letter to us, which I might, if I desired, read. Waiving aside the formalities of introduction, Mr. Mitchell says:

"Your organization is one of the mainsprings of American progress and business development, and it would have been my pleasure as well as my recognized duty to have been with you had conditions permitted."

I have a letter addressed to our Secretary by the Chairman of the Interstate Commerce Commission, who acknowledges with thanks his invitation, and expresses his appreciation for our thoughtfulness in extending to him an invitation. He concludes with the regret that "pressure of work here in Washington will not make it possible for me to be with you." It is signed by Mr. Lewis, Chairman of the Interstate Commerce Commission of the United States.

I have before me a message from Mr. Charles M. Schwab, which I shall read:

"In recent years American railroads have attained the highest standard of performance in their history. Yet railroad men are the first to realize that these standards must be continually improved upon in order to meet successfully the future transportation requirements of the country. Research is being carried on to an intensive degree, particularly in such matters as electrification, air and motor transport, and traveling safety and comfort. The railroads are studying future problems more carefully than ever before, all with the one objective of improving their service in every possible detail.

"It is that spirit of pioneering that is to-day most characteristic of our industrial activity at its best and continues to make for progress in this country. We can never be satisfied that what we have achieved is sufficient. In order to establish permanent institutions we must always be prepared for change.

"We have only to look about us to-day to know that such effort is not in vain. Our railroads are realizing amazing results. Men are being paid higher wages, conditions of work are being made better, the public is getting better service. There is economy, profit and progress all around.

"All this has contributed inestimably to our present high standards of living. Not only are the railroads the backbone of our industrial organization, distributing our vast resources and redistributing our manufactured products, but they extend this service to almost every detail of our private life. The food we eat, the newspapers we read, practically all of the modern provisions we count upon are brought to us in every corner of the country by the railroads.

"The steel industry in general is not far removed from partnership in this effort towards higher standards of service. Using approximately a fifth of our total production, the railroad industry is virtually our largest single customer. The significance of this relation between two of the nation's leading industries is more than merely economic. It is only through co-operation, and through service based on a greater understanding of one another's needs, that American industry can advance in the future as it has in the past. And, it is by such methods that we are destined not only to promote individual happiness but also to maintain our position of leadership among the nations of the world.

"C. M. Schwab."

The Bulletins are in your hands. It has been our experience that by watching these Bulletins closely and turning page for page, you can more readily keep up with the text. These matters are highly technical and it is not at all easy to grasp what the speaker has in mind. I would recommend to you very strongly that you do this all the way through these sessions.

I would say that while we have generally quiet here, this meeting is a meeting of a learned society; this meeting is a result of a year's work. I say to you in behalf of the committees and for each individual worker thereon that you give to them your closest attention and your greatest quiet. Those who have worked on committees can realize how disconcerting it is when you do not get the close attention that is deserved by these excellent reports.

The Coliseum down on Wabash Avenue has an exhibit that is worthy of your attention and your attendance. They have their exhibit the same week we hold our meetings, and I recommend to you strongly, if you find an opportunity, to visit the Coliseum. The National Railway Appliances Association will welcome you there, and I cannot speak too strongly of the educational benefit that you will gain by going to that Coliseum exhibit and seeing the various things presented there for your information.

The registration of the membership is very desirable. We want the registration as accurate and as complete as possible. We want to see how many are here. Remember, this is not a closed session. Your are welcome, your friends are welcome, and you should invite your friends here who are interested in us and in our work.

We now come to the question of our first committee. It is a pleasure to reach this point, and I now call to the stand the Special Committee on Standardization.

Mr. W. C. Cushing of the Pennsylvania will now deliver the report on Standardization. He is the Chairman.

(For Report, see pp. 65-121.)

The President:—The Committee on Water Service and Sanitation will please come forward. Mr. C. R. Knowles, Superintendent Water Service, Illinois Central Railroad, Chicago, is Chairman of this Committee. This Committee has 39 members and represents 36 railroads. There are fourteen states represented in the geography of this Committee.

(For Report, see pp. 123-209.)

The President:—The Committee on Roadway will please come forward.

I wish to say if any of you want to get the Bulletins they are available in our office on this floor. They should be used freely.

The Committee on Roadway consists of 31 members representing 19 states and 24 railroads, a university and a manufacturing company. Mr. C. W. Baldridge, Assistant Engineer, Atchison, Topeka & Santa Fe Railway, is Chairman of the Committee, and will present the report.

(For Report, see pp. 211-243.)

The President:—I wish to state at this time that the order of business will be definitely postponed until two o'clock. The Committee will remain here.

At this time we have the address on the Southern Pacific Bridge, and if you will just remain seated, Mr. C. R. Harding will please come forward.

(Mr. Harding then commented on his paper published in Bulletin 315, entitled "Southern Pacific Company's $12,000,000 Bridge Across Suisun Bay," illustrated with lantern slides.)

AFTERNOON SESSION

The President:—When we adjourned, we were discussing the report of the Committee on Roadway in Bulletin 310. You will please turn to page 211. We were discussing and had just finished on page 213 certain remarks addressed to the reports of Appendix B under the head of Deformation of Roadbed. At this time we will invite any further observations to be made on Appendix B. Please note that there is nothing before the house which requires any motion on that particular Appendix B. You have voted already to have it referred back.

Are there any further observations in connection with Appendix B? There being no further observations, we will proceed with the next item in this Committee's work.

The President:—I wish to state that Mr. Baldridge's remarks on what is assigned for next year might not be known to you. If you will look at Bulletin 312, you will find in the last part of that Bulletin the work outlined for the current year. This is given so that every one of the members will know that every Committee has been instructed to do something. It is gratifying to know that these instructions were issued as far ahead as possible.

Before we get into this next report the Chair will recognize one of our members of the B. & O. Miss Dennis of the Baltimore & Ohio Railroad.

Miss Olive W. Dennis (Baltimore & Ohio):—Mr. President and Fellow-Members of the American Railway Engineering Association: Last year for the first time I attended a meeting of this Association as a member. The best evidence I can produce that I enjoyed the experience is the fact that I have come back. Thank you. (Applause.)

The President:—We will now have the report of the Committee on Ballast. Mr. E. I. Rogers, of the Peoria & Pekin Union Railway, is Chairman of this Committee.

(For Report, see pp. 245-257.)

The President:—The Committee on Ties will come forward. Mr. W. J. Burton of the Missouri Pacific is Chairman of the Committee. On this Committee we have thirty-four members, of which there are 28 railroads represented, including eighteen different geographical states. Mr. Burton will now give the report.

(For Report, see pp. 291-321.)

The President:—The next report is that of the Committee on Uniform General Contract Forms. This Committee consists of nineteen members representing fifteen railroads, and the geographic representation is that of thirteen states. This is to be presented by Mr. J. C. Irwin, Chairman of the Committee.

(For Report, see pp. 323-343.)

The President:—The Committee on Shops and Locomotive Terminals will please come forward. Please refer to page 345, of Bulletin 311, for this report. This Committee consists of thirty-four members representing twenty-four railroads and sixteen geographical states. Mr. A. T. Hawk, Chairman of the Committee on Shops and Locomotive Terminals, will present the report.

(For Report, see pp. 345-379.)

The President:—We now come to the report of the Committee on Clearances.

(For Report, see page 258.)

The President:—Now comes the Committee on Co-operative Relations with Universities, headed by Mr. R. H. Ford. I wish to say this Committee consists of twenty-eight members representing fourteen states geographically. Will the Committee please come at once to the stand?

(For Report, see pp. 1229-1230.)

The President:—I now wish to close this evening session with the full thanks and appreciation of this body to the Committee now leaving, and with urgence that you will come to this room to-morrow morning at 9:00 o'clock sharp. The meeting is now adjourned.

(The meeting adjourned at 5:10 o'clock.)

WEDNESDAY, MARCH 6, 1929

MORNING SESSION

The President:—The Association will please come to order. This is the second day of our three-day annual session.

You will note in this morning's issue of Railway Age what we have accomplished in the registrations of guests and members up to last night. As I recall, the figures approximate 1,000.

We will now proceed to the regular order of the day. I shall call to the platform the Committee on Rules and Organization. Mr. W. C. Barrett, Chairman, will present the report.

(For Report, see pp. 381-389.)

The President:—I wish to state, as you probably know, that Mr. R. H. Aishton, President of the American Railway Association, has been prevented from coming here to-day. As you know, the American Railway Engineering Association functions as the Construction and Maintenance Section of Division IV—Engineering, of the American Railway Association, and we function as an instrumentality of that Association, of which he is President.

Mr. Aishton has directed a letter to us in his absence. It is in Mr. Fritch's hands, and Mr. Fritch will read this letter to you from Mr. Aishton.

"Dear Mr. Faucette: It is a matter of most sincere regret to me, at the last moment, that I find I will be unable to get to Chicago next week to attend the Annual Convention and dinner of the American Railway Engineering Association.

"One reason for wanting to be there is that I feel a word of appreciation is due you and your associates for the very splendid work that has been accomplished by the Engineering Division under your able and energetic leadership in the past year; also for the very excellent work of the active committees dealing with various subjects, and particularly to indicate to you all the helpfulness of the spirit of cooperation that you have evidenced not only with the activities of the American Railway Association but particularly with the representatives of public interests. In this manner you have helped bring about better understandings, helpful and beneficial alike both to the railroads and the public. Your accomplishments in this direction constitute a record in which you may well take pride.

"Sorry that I cannot be with you to express this thought to your membership personally at the meeting.

"With my assurance that it is a pleasure to be of help to the Association and to the Engineering Division at any time, and with my kind personal regards and best wishes to you all, I am

"Sincerely yours,

"(Signed) R. H. Aishton."

(Applause.)

The President:—Mr. Aishton's communication will be acknowledged with thanks.

The Committee on Yards and Terminals will please come forward. Please refer to Bulletin 312, page 391. The report will be presented to you by Mr. J. E. Armstrong, the Chairman.

(For Report, see pp. 391-410.)

(First Vice-President Louis Yager in the Chair.)

Vice-President Louis Yager:—Will the Committee on Rivers and Harbors please come forward?

As you probably know, this is one of our younger committees. They are dealing with some very important subjects and they are our point of contact with some very important matters of flood control which are very much in the public notice. The Committee's report will be submitted by the Chairman, Col. Wm. G. Atwood.

(For Report, see pp. 259-290.)

Vice-President Louis Yager:—Will the Committee on Wood Preservation please come forward?

The Committee on Wood Preservation is composed of twenty-nine members representing seventeen railroads, seven industrial concerns and includes two consulting engineers. Geographically the membership is distributed over fourteen states and the Dominion of Canada.

Their report will be found in Bulletin 313. The report will be submitted by Mr. Shepherd, the Chairman.

(For Report, see pp. 653-702.)

Vice-President Louis Yager:—The next order of business is the report of the Committee on Stresses in Railroad Track. I am sure that you always look forward to a report from this Committee, and as usual, that report will be presented by Dr. Talbot.

(For Report, see page 1228.)

Vice-President Louis Yager:—Thank you, Dr. Talbot, for your very interesting forecast of your report.

(President Faucette resumed the Chair.)

The President:—The Committee on Grade Crossings will please come forward. The report will be presented by the Acting Chairman, Mr. Frank Ringer.

(For Report, see pp. 487-507.)

AFTERNOON SESSION

(Past-President J. L. Campbell presiding.)

Past-President J. L. Campbell:—The convention will come to order.

Will the Committee on Grade Crossings come to the platform? The report of the Committee will be continued by the Chairman, Mr. Ringer.

(President Faucette resumed the Chair.)

The President:—I take pleasure now in announcing the report of the Tellers. Mr. Fritch will take the floor and read it to you.

Secretary E. H. Fritch:—The report of the Tellers is as follows:

REPORT OF THE TELLERS

"We, the Committee of Tellers, report the following as the result of the count of ballots:

For President:

*Louis Yager	1477
B. Herman	1
L. W. Baldwin	1

For Vice-President:

*L. W. Baldwin	1476
R. H. Ford	2
Louis Yager	1

For Secretary:

*E. H. Fritch	1479

For Treasurer:

*F. J. Stimson	1479

For Director (three to be elected):

*J. E. Armstrong	678
*C. C. Cook	557
*Frank Ringer	540
C. R. Harding	535
T. J. Skillman	478
J. E. Willoughby	444
C. E. Smith	394
C. B. Brown	376
D. J. Kerr	233

For Members Nominating Committee (five to be elected):

*C. W. Baldridge	1218
*A. N. Reece	1007
*H. C. Crowell	845
*W. T. Dorrance	783
*C. H. Tillett	697
J. C. Irwin	685
J. E. Teal	677
C. M. McVay	515
R. C. Young	476
C. C. Westfall	4
J. R. W. Davis	1

Respectfully submitted,
H. E. Silcox, *Chairman.*

Note—Names prefixed by asterisk declared elected.

The President:—This gives you the officers for next year and you now have the full ticket. You understand that Mr. G. D. Brooke, now Second Vice-President, automatically succeeds to the First Vice-Presidency when Mr. Yager takes over the Chair on Thursday afternoon.

We shall now call to the stand the Committee on Track, Mr. J. V. Neubert, Chairman. This Committee is composed of forty-eight members, thirty railroads and sixteen states geographically.

From this point on, Mr. Brooke, our Vice-President, will take over the session and will carry it through until four-thirty.

(Vice-President G. D. Brooke assumed the Chair.)

Vice-President G. D. Brooke:—Mr. Neubert, will you present the report of the Committee on Track?

(For Report, see pp. 853-951.)

Vice-President G. D. Brooke:—The Committee on Electricity and Electrical Section of Division IV will please come forward.

The meeting will now be turned over to the Electrical Section of Division IV of the American Railway Association. Mr. Sidney Withington, Chairman, will take charge of the meeting.

(For Report, see pp. 411-485.)

Vice-President G. D. Brooke:—The Committee on Signals and Interlocking will please come to the platform.

(For Report, see pp. 509-548.)

THURSDAY, MARCH 7, 1929

MORNING SESSION

The President:—The first on the program is the report on Iron and Steel Structures. Will that Committee please come forward. We will now have the report of the Committee presented by Mr. A. R. Wilson, Engineer of Bridges and Buildings, Pennsylvania Railroad.

(For Report, see pp. 953-1104.)

(Vice-President Louis Yager in the Chair.)

Vice-President Louis Yager:—The report of the Committee on Wooden Bridges and Trestles will be found in Bulletin 314, page 1145. The report will be presented by Mr. W. E. Hawley, the Chairman.

(For Report, see pp. 1145-1227.)

(President Faucette resumed the Chair.)

The President:—Before we call the next Committee we are going to have a few remarks by Mr. J. M. Johnson, of Chicago. Mr. Johnson has asked for ten minutes, and I have taken pleasure in according Mr. Johnson this privilege to acquaint you with the plan of the World's Fair Speakers' Bureau, the idea being that this Fair, if held, would be in 1933. I will ask Mr. Johnson to come to the stand.

Mr. J. M. Johnson:—I should like to have had the time to paint for you a word picture of what this great exhibition is going to be, but time being limited, it will be necessary to touch a little on the high spots.

The World's Fair Speakers' Bureau is composed of a group of volunteers who make it their business to acquaint the world with this great birthday party that we are going to have here in 1933. We are not going to have a World's Fair as they have been in the past, because this is an age of cooperation. One industry will not compete against another. Industry will cooperate, and the various groups will show the advancement that has taken place, the advancement in science, the things that tend to make life worth while and take the hardships away from the home.

Science to me may not mean what it does to you. When I think of science, I think of the horse-drawn street car to the present system of fast transportation, whereby a man is enabled to move out in the open spaces, take his family out in the fresh air. Science to me means the coal range to the gas range. It means the washboard to the motor-driven washing machine.

This Chicago's World's Fair will portray advancement. Only recently, as you men know, the Baltimore and Ohio Railroad had an exhibition portraying the advancement of railway transportation, and in three weeks' time more men and women visited that fair than visited the Philadelphia Exposition in three months' time.

People today are not interested in freaks and fakes; they are interested in progress, in the things that will affect us and how life will affect us in five or ten years from now.

In coming here to you men, I appeal for your support. We expect to have here 100,000,000 people and it will rest on your shoulders to bring the great percentage of this group of people here.

No doubt you know more about the World's Fair than I do, but those of you who are from foreign soil, we also ask you to help support our World's Fair. We would like to have it known all over the world. We are making hard efforts to do it, and I believe through a group of men such as this, it is probably the greatest medium we have to aid in a cause of this kind.

This World's Fair will be held on the shores of Lake Michigan, or rather a group of islands. We assure you from our architects' vision that it will be the most beautiful spectacle the world has ever known. We propose to offer to the people of the World's Fair what the world's people will talk about for many years to come. We are going to use the water of the lake in forming canals through the various buildings that we will have, and also use electric lights to play on this water. We expect to do something that has never been done before in the line of electrical display.

We will not have fakes and freaks because we want the world to believe that our World's Fair is to be a continuation of some great institution of learning. It will be an education, and I suppose, a trip around the world. But we will have amusement to ease the tired mind. We all like a little fun. We will have the best music, and, of course, all the good in the world's art. I suppose we will have exhibitions like they had in 1893, such as eskimos, the streets of Cairo, and all those things, because some people like that kind of amusement. We will have all the great athletic contests that will take place in that year. We would like to have the Olympic games but we are one year late for that.

Gentlemen, I thank you very kindly for your kindness in listening to me. I urge you again to help boost our World's Fair. (Applause.)

The President:—We thank Mr. Johnson for his presentation of the picture of 1933 in Chicago. He properly says the burden of this transportation rests upon the shoulders of the carriers of this country.

The next Committee will please come to the platform, the Committee on Records and Accounts. This report is found in Bulletin 313, page 575. Mr. J. H. Hande is Chairman and will present the report.

(For Report, see pp. 575-652.)

The next Committee to report is that of the Buildings Committee. Mr. Frank R. Judd, the Chairman, will present the report to the Association.

(For Report, see pp. 549-574.)

AFTERNOON SESSION

The President:—The first Committee to report this afternoon will be that of the Committee on Rail. Mr. Earl Stimson, the Chairman, will present the report to you.

(For Report, see pp. 1231-1324.)

The President:—The Committee on Economics of Railway Location will please come to the platform. Mr. F. R. Layng, Chairman of the Committee, will give you the report.

(For Report, see pp. 817-1892.)

The President:—The next Committee is the Committee on Economics of Railway Operation. Mr. James M. Farrin, the Chairman, will present the report to you.

(For Report, see pp. 703-780.)

The President:—Will the Committee on Economics of Railway Labor please come to the stand? The report will now be presented to you by the Chairman, Mr. A. N. Reece, of the Kansas City Southern.

(For Report, see pp. 1105-1144.)

The President:—Gentlemen, this last report completes the regular order of reports of our several committees. They have been received with interest and represent a great deal of work. They have been in detail in many cases. To these committees this Association owes its standing and its reputation for the work performed by them. The quality of the work is without a peer, and I am pleased to record that this Association values highly the efforts of every committeeman, its chairman and its sub-chairman.

With regard to the registration, I have been furnished this report which I will read. A total of 51 members and 47 guests registered yesterday, bringing the total registration for the convention to 1001 members and 402 guests, a combined total of 1403 as of this hour today. This compares with a total registration last year of 968 members and 348 guests, or a combined total of 1316; and of 925 members and 346 guests, or a total in 1927 of 1271.

This present year is the first year in the history of this, our Association, in which the registration of its members alone has exceeded the total number of 1000, and a total registration of over 1400.

We now come to the conclusion of the regular stated business and will take up in order the matter of New Business. Is there anything appearing first in the order of new business?

Mr. Earl Stimson (Baltimore & Ohio) :—Mr. President and Members: It is my happy privilege, this afternoon, to say a word of appreciation, on behalf of the American Railway Engineering Association, to one of our distinguished members. He has given of his time and his energy, and of his knowledge, serving as a committee member, committee chairman, Director, Vice-President and President and now, after eleven years' service on the board, he is automatically retiring, having completed his fifth year as Past-President.

Four years ago this same member, in very gracious words which I can but poorly imitate, expressed the Association's appreciation of my humble services, and after he had so expressed it in his well-chosen words, words that may all too soon be forgotten, he expressed it in a more enduring form by presenting me with a handsome bronze medal.

Mr. Campbell, it is now my great pleasure to make a like presentation to you. (Applause.)

Past-President Campbell:—Mr. Stimson, Mr. President and Friends: It has been my good fortune to have attended every convention of this Association since I became a member more than twenty years ago.

As I approach the reminiscent time of life and make some review of the past, I find that life has been well worth-while. This Association and the friends which I have found here have made large contribution to that worth-whileness, and I now express grateful appreciation.

On former occasions such as this, I have been on the delivery end. Now I find myself at the receiving end, but the good sport will not stall on his own medicine. I take it with relish and thanks.

I have some familiarity with the significance of this medallion, having been on the delivery end of it, as stated by my friend, Earl Stimson.

On one side of the medallion there are four figures—the figure of Time, the figure of Industry, the figure of Ability, and the figure of History.

Industry is shown in the act of crowning Ability. History is recording the fact on the page of Time. By this you generously imply that I am at least a distant relative of Ability. May blushing Modesty demurely mantle my brow.

On the other side of the medallion there are two trees—the laurel and the oak, one on one side, one on the other, and their curving branches meet over the middle, forming an arch in which the laurel leaves of Honor mingle with the oak leaves of Strength.

Beneath and within this arch, you do me the honor of inscribing my name. This evidence of your regard so attunes the strings of my heart that they vibrate to all the melodies of friendship as the fingers of your friendship play upon them.

Last night at the annual dinner I made an application from the Twenty-third Psalm to our worthy President. Since I am now also on the receiving end, let me make the application to myself. My cup also runneth over.

Surely goodness and mercy shall also follow me all the days of my life, and I also shall dwell in the hearts of my friends forever. (The audience arose and applauded.)

Mr. F. H. McGuigan, Jr. (Prudential Life Insurance Co.) :—Mr. Chairman, I wish to offer a resolution:

"Resolved, That the members of the American Railway Engineering Association, in convention assembled, desire to place on record their hearty appreciation of the capable manner in which this convention has been presided over by Mr. W. D. Faucette, and of the efficient administration of the affairs of the Association during his occupancy of the Presidential Chair; and

"That this resolution be spread upon the Minutes of the meeting, and a suitably engrossed copy presented to Mr. Faucette."

Past-President D. J. Brumley (Illinois Central) :—I second the motion.

(The motion was carried by a rising vote.)

Mr. H. L. Ripley (New York, New Haven & Hartford) :—During the thirty years, approximately, of the life of this Association, many of its members have done their work well and deserve the praise and the thanks of this Association, but one among us has done supremely well, and I want to offer the following resolution:

"Resolved, That the American Railway Engineering Association, in convention assembled, does hereby express its appreciation for the untiring efforts and the sound business judgment which has been displayed in the affairs of his office by Mr. E. H. Fritch, our very able and always genial Secretary."

Past-President D. J. Brumley:—I second the motion.

(The motion was carried by a rising vote.)

The President:—I want to say what Mr. Ripley has said has occurred to the Board and your President throughout the whole administration. I as one want to concur heartily in what you have said to Mr. Fritch. I was hoping Mr. Fritch would take occasion to say something, but I want to say that he is very modest, and I might say, super-modest.

Are there any other resolutions?

Mr. L. L. Lyford (Illinois Central) :—I want to offer the following resolution:

"Resolved, By the American Railway Engineering Association, in convention assembled, that its appreciative thanks are hereby extended to the National Railway Appliances Association for the interesting exhibit of the railway devices and appliances; to the management of the Palmer House, and to Mr. L. R. Bell and Mr. Juan Muller and their staffs, for the capable manner in which the convention has been handled and for the courtesies extended to the members and guests."

(The motion was regularly seconded, was put to a vote and carried.)

Mr. C. R. Knowles (Illinois Central) :—I wish to offer a resolution:

"Resolved, By the American Railway Engineering Association, in convention assembled, that its thanks are hereby extended to Honorable Vincent Massey, Honorable James S. Parker and W. R. Cole, Esq., for their most excellent and instructive addresses at the annual dinner on the evening of March 6."

(The motion was put to a vote and carried.)

Mr. H. M. Stout (Northern Pacific):—I think all of us have been impressed with the excellent way in which the management of this convention has been carried on, provisions for the sessions as well as the dinner last night. Therefore, I have pleasure in offering this resolution:

"Resolved, By the American Railway Engineering Association, in convention assembled, that its most appreciative thanks be tendered the Committee on Arrangements, for the very able manner in which they have handled all matters in connection with the convention and dinner."

(The motion was regularly seconded, was put to a vote and carried.)

The President:—Are there any other resolutions to be presented?

Mr. Hadley Baldwin (Cleveland, Cincinnati, Chicago & St. Louis):—I desire to offer for the attention of the convention the following resolution and move its adoption:

"Resolved, By the American Railway Engineering Association, in convention assembled, that its thanks are hereby extended to Major-General Edgar Jadwin, O. H. Caldwell, Esq., and C. R. Harding, Esq., for their interesting addresses during the convention."

(The motion was regularly seconded, was put to a vote and carried.)

Mr. Louis Yager (Northern Pacific):—I desire to offer the following resolution:

"Resolved, By the American Railway Engineering Association, in convention assembled, that the thanks of the Association be extended to the management of the Great Northern Railway for the display of instruments used in the location and construction of the Cascade Tunnel, the greatest railroad achievement of the year."

(The motion was seconded, put to a vote and carried.)

The President:—Are there any further resolutions?

Mr. C. E. Armstrong (Norfolk & Western):—I wish to offer this resolution:

"Resolved, By the American Railway Engineering Association, in convention assembled, that its appreciative thanks are hereby extended to the Chairmen, Vice-Chairmen and members of the several committees for their labors during the past year and for the valuable reports presented to the meeting and to the technical press for the many courtesies extended during the year and during the convention."

(The motion was seconded, put to a vote and carried.)

The President:—Are there any further resolutions or any other items of new business to come before the convention?

Secretary E. H. Fritch:—An amendment to the Constitution was submitted to the membership involving a change in Article II of the Constitution for requirements for membership. The amended section reads as follows:

"Section 2. A Member shall be:

"(a) Either a Civil Engineer, a Mechanical Engineer, or an official of a railway corporation, who has had not less than five (5) years' experience in the location, construction, maintenance or operation of railways, and who, at the time of application for membership, is engaged in railway service in a responsible position in charge of work connected with the location, construction, operation or maintenance of a railway (this is the addition) *or an Engineering Editor of a Railway Magazine;* provided, that all persons who were Active Members prior to March 20, 1917, shall remain Members except as modified by Article II, Clause 9."

The result of the letter-ballot was 648 for the amendment and 50 against the amendment. The amendment, therefore, carries and becomes effective at the close of this convention.

The President:—You have heard the vote in regard to the amendment. It so stands in the record.

Is there any further new business? Are there any other resolutions or matters to be presented? If not, the matter of the election of officers and installation thereof, following the election and the tellers' report, now comes.

(The Secretary re-read the report of the Tellers.)

The President:—Gentlemen, you have heard the list of officers, and I come now to a very pleasant duty; I come now to the end of this year's convention. I am pleased to appoint and ask Mr. Brumley, Past-President, and Mr. Stimson, Past-President, to bring to the stand the selection of your votes on whom these responsibilties will be placed as your next President, Mr. Louis Yager, of the Northern Pacific.

(The audience arose and applauded while President-Elect Yager was being escorted to the platform.)

The President:—Mr. Yager, it is a pleasant duty and a proper act on my part to pass to you on whom the responsibilities of this Association will devolve, the duties of President. In doing so I want to say that you are honored by an Association unequaled in existence in this world. You have shown yourself capable of these responsibilties; you have the proper equipment; and you are one on whom your fellow-members have placed willingly and gladly the duties of that great office.

I come now to pass to you at this instant this office, and you will have with it the greatest co-operation possible, all the help that you want, the advice and assistance of 3000 men. In doing this I want to hand to you as a token and emblem of this office a gavel which I have taken the liberty to have made for you, a gavel that with my good wishes and with the good wishes of this Association I now present, not intrinsic in value but a symbol of our good wishes and the good wishes of every member and every man who has had this position as President.

With this gavel I pledge you my support; I pledge you every good wish and support, Mr. Yager, of every member. You will make a successful administration and I honor you in passing to you at this instant this Chair, which you so deservedly have succeeded to.

(The audience arose and applauded.)

(President-Elect Louis Yager took the Chair.)

President-Elect Louis Yager:—Mr. Faucette and Fellow-Members: The hour is getting late. Many of you with us have put in three rather strenuous days. There is still considerable work to be done before we can finally conclude this session.

We are gratified that so many of you have found it possible to remain to the closing hours of our convention, and we do not desire to do anything that will discourage you from similar action in the future. I, therefore, have no desire to detain you further at this time in listening to a speech even though I were able to make one.

My membership in this Association is in no respect different from that of all others. It has been a continuing opportunity for professional development and a privilege of contributing service to the general welfare. I appreciate, more than I can express in words, the honor which you have conferred upon me in making me President of this Association.

As the character of a man may be suggested by the company he prefers, so the success of an executive is indicated by the type of officers with whom he is surrounded. You have selected the official family, of whom I am one. In recognition of the confidence expressed in your selection, we pledge to you our best efforts in the fulfillment of our obligations. I know that you will extend to us the same generous support and co-operation which you have given to our predecessors. Through your sustained interest in the work and solicitude for the welfare of the Association, we will be able to maintain the high standard of service and professional ideals which have characterized our Association's activities.

Fellow-members, I thank you.

(The audience arose and applauded.)

The President:—As there is no further business to come before you, I declare the Thirtieth Annual Convention adjourned *sine die*.

(The meeting adjourned at five o'clock.)

(The thirty-first annual convention of the American Railway Engineering Association will be held at the Palmer House, Chicago, March 11, 12, 13, 1930.)

E. H. Fritch

Secretary.

COMMITTEE REPORTS

REPORT OF SPECIAL COMMITTEE ON STANDARDIZATION

W. C. Cushing, *Chairman;*
J. E. Armstrong,
Col. Wm. G. Atwood,
C. W. Baldridge,
W. C. Barrett,
[1]F. L. C. Bond,
W. J. Burton,
J. M. Farrin,
Robert H. Ford,
J. H. Hande,
A. T. Hawk,
W. E. Hawley,
J. C. Irwin,
F. R. Judd,
[1]J. R. W. Ambrose, *Vice-Chairman;*
[1]*E. B. Katte* (died 19th July, 1928),[2]
C. R. Knowles,
[1]F. R. Layng,
J. V. Neubert,
W. M. Post,
A. N. Reece,
C. P. Richardson,
E. I. Rogers,
F. C. Shepherd,
Earl Stimson,
F. J. Stimson,
A. R. Wilson,

Committee.

To the American Railway Engineering Association:

Your Special Committee on Standardization submits the following information as its annual report for the year 1928-1929:

FORCE OF NUMBERS IN COMMITTEE WORK

Last year in its report the Committee reprinted "Why is a Committee," a very clever digest and important reminder of a committee's duties, by the Electric Club in Los Angeles, and this year, for the same reasons of cleverness and an interesting introduction to our prosaic study of standardization, we offer a careful balancing of the value of numbers in committee work, by the Honorable B. H. Meyer, Interstate Commerce Commissioner, over a long period of service with that body:

> "A body which is representative in its functions must necessarily be large enough to insure proper representation of all the different interests which should be presented. My experience points to seven as the number which combines the highest degree of efficiency in operation with the highest degree of soundness in conclusions. Where a commission acts through sub-divisions as we do, a larger number than seven is required to furnish sufficient members for the necessary sub-divisions. Eleven, our present membership, accomplishes this. Three men can act expeditiously and with respect to decisions that follow precedent or that do not involve momentous issues, can arrive at judgments which are likely to be sound. Five men require more time for an exchange of views but together they possess a sounder deliberative judgment and sufficient variety in point of view and methods of reasoning to be able to dispose of larger questions. Five can handle safely questions of large import. Issues that are

[1]Members of the First Committee, 1919.
[2]See page 102 for Memorandum of Affectionate Tribute.

Bulletin 310, October, 1928.

novel or momentous can be disposed of better by seven men than by five because the seven collectively represent something which ordinarily five may not possess. Seven men require more time than five. Nine men ordinarily do not represent sounder points of view or a higher degree of deliberative judgment than seven and therefore add nothing to the quality of the judgment rendered. The same is true of eleven men. Since both nine and eleven require more time than seven, the larger numbers diminish the efficiency of the body, but it is necessary to have a number larger than seven in order to provide the members of different divisions. We act through five or six different divisions, each composed of three men, the same men acting on different divisions. Bodies composed of larger numbers can not retain the same quality of mutual understanding, solicitude regarding the view of others, facility in arriving at conclusions which smaller bodies possess. Larger numbers affect the mental attitude and possibly mental processes."

Again, in lighter vein, the following from the *Public Ledger,* Philadelphia, is highly appropriate for notice by this Committee:

"BUSINESS PHILOSOPHY"

By William Feather

"The Public Printer at Washington has reported that 'Authors' corrections' cost the Government $250,000 last year.

"'Authors' corrections' means changing your mind. It's what is done on second thought.

"The wonder is that the cost was so low.

"Most people who indulge in second thoughts are the kind who don't do much thinking when a subject is presented to them for first thought. Knowing they will have a chance to change their mind, they dodge the pain of thinking the first time.

"I have often wondered why so many competent men as chairmen of committees let important matters go until the fifty-ninth minute. The answer seems to be that committee members will not think until they have to. A decision that can be changed is no decision at all. Let a decision be made seven days in advance of its taking effect, and within the week five out of seven members will change their minds.

"The waste involved in postponing thinking until the remotest possible moment is colossal. The Public Printer's figure is merely a hint."

Our report this year follows the outline of work submitted and approved in the annual report to the Association, year 1927-1928.

PART I—ANNUAL REVIEW OF REVISION OF MANUAL—INCORPORATED PRACTICES

These notes refer to the reports of committees submitted and discussed at the Annual Convention, March 6th, 7th, 8th, 1928.

Committee I—Roadway

An important addition to the "Manual of Recommended Practice" was the "Specifications for Metal Fence Posts." In view of the extensive use of such posts, it is highly important to place the purchase on a specification basis in order to have a measure of selection from such a numerous assortment of designs.

In addition the reports for information gave useful data in connection with special subjects.

Committee II—Ballast

No additional "practices" for the Manual were brought forward, but progress reports gave promise of interesting information in contemplated investigations.

Committee III—Ties

Two reports of great value were submitted, "Anti-Splitting Devices" for ties, and "Size of Holes for Pre-Boring," which will be of help in settling upon these practices. They are based on careful laboratory study, in the first case that of The Pennsylvania Railroad and in the second that of the Santa Fe System.

The annual reviews of "Substitute Ties" by this Committee have accumulated information of continuing value, but are so scattered through the Proceedings that it is quite laborious to collect information upon specific designs when desired. One can never get away from the study of the history of a problem if he expects to progress in the future, and, in the case of many appliances, that is the "Study of the Scrap Pile." In order to make all the past work of the Committee readily and quickly available, this Special Committee on Standardization recommends the following procedure for its report for the Annual Convention of 1930. This will be a "roundup" of 30 years of experimental information upon substitute ties:

(1) Have an accurate and complete plan of each substitute tie given traffic tests in track by a railroad company, furnished by the company which made the trials. This will distribute the work.

(2) Write specific and complete instructions for making the plans, especially using the same scale, so that they will be presented alike.

(3) Have your Committee collect from the previous reports the life service of each one of these ties to go with its own plan. In case of incompleteness, call upon the road.

(4) In making the "life service" report, analyze causes of failure, using illustrations, and point out matters of interest in the review.

Committee IV—Rail

Mr. McDonald furnished the Committee with additional important information about his special track—study of the "Cause and Prevention of Rail Battering." Further information may be expected.

The work of this Committee is a continuing progress report, and is so important that it may be considered as a unit of the official organization of the American Railway Association.

Committee V—Track

This Committee has continued its good work of adding to the Manual plans for solid manganese steel crossings, and movable point crossings, rail-bound manganese steel frogs, at the same time modifying its plans already recommended practice.

It added also "Track Construction in Paved Streets" and "Foundations Under Railway Crossings."

Committee VI—Buildings

Additional sections concerning different kinds of exterior paving and interior flooring of its comprehensive plan for providing "Specifications for Railway Buildings" were submitted as advance information for the membership discussion pending final incorporation in the Manual at a later date.

The principal contemplated changes of recommended practice deal with the Specifications for Railway Buildings and are likely to be made in Section 5—Brickwork, 6—Stone Masonry and Cut Stone, 13—Carpentry and Millwork, 14—Lathing and Plastering, 15—Marble and Tile Work, and 16—Painting and Glazing.

Committee VII—Wooden Bridges and Trestles

An important revision of the "Specifications for Timber Piles" was accepted for the Manual.

The "Simplification of Grading Rules and Classification of Timber for Railway Uses" was adopted by the Association in 1926 for *softwood* lumber only; that for *hardwood* may be ready in a year or two. The Committee now points out that "the present job is to put these standards into use."

Further reference to this work is made under American Railway Association.

Committee VIII—Masonry

An important addition to the Manual was made by the acceptance of specifications in connection with "Flexure of Reinforced Concrete T-Beams" as part of the Committee's comprehensive plan for presentation of "Principles of Design of Concrete, Plain and Reinforced, for Use in Railroad Structures." It is highly important to work in unison with the Joint Committee of Engineering Societies, and to have that Committee make revisions where shown to be desirable.

Committee IX—Grade Crossings

The Committee has furnished a large fund of information necessary to be known in connection with grade crossing protection and elimination. A revision of the adopted plan for "Highway Crossing Sign" was sent to letter-ballot which will be announced at the Thirtieth Annual Convention.

Committee X—Signals and Interlocking

This Committee is the Signal Section of Division IV—Engineering of the American Railway Association, and its authoritative work is approved or rejected by that body. Its relationship with this Association is that of "Reporter," and it submits an annual statement in the form of an index of its recommended practices, and summaries of the progress being made in the new developments of the art under way. The subject, therefore, of Automatic Train Control has been elaborately reviewed, and the "Code of Colors and Forms for Traffic Signals for Highways and Vehicles" of "The National Conference on Street and Highway Traffic Safety," organized under the auspices of the United States Department of Commerce, was printed in Proceedings, A.R.E.A., Vol. 29, 1928. This "Code" was adopted by the American Engineering Standards Committee as a national standard November 15, 1927.

Committee XI—Records and Accounts

Inasmuch as the Interstate Commerce Commission has full and complete authority over methods of railway accounting and the valuation of railway investment, the main work of this Committee is keeping the members informed upon the orders issued from time to time. These two subjects embraced the main part of the work last year, and the thoroughness of the presentation is indicated by the number of pages of the Proceedings required, 177.

Committee XII—Rules and Organization

In order to have the new edition of the Manual as correct and complete as possible, the principal work was devoted to the revisions of its recommended practice.

The work of Committee XII during the past seven or eight years has been very largely the preparation of a Manual of Rules for the Guidance of Employees of the Maintenance of Way Department. This Manual cannot be and should not be ever finally completed, as progress in Maintenance of Way methods and practices from year to year will necessitate annual revision of some parts of the Manual. For the past three years this Committee has been devoting its attention primarily to Rules for Inspection, Construction and Maintenance of Structures. This work has been found to be very difficult of accomplishment due to the task of discriminating between what is properly a rule and what is properly a specification.

Many railroad companies have already made use of the Manual Rules for the Guidance of Employees of the Maintenance of Way Department prepared by this Committee, either in whole or in part, but the Committee has no definite information as to the exact number.

Committee XIII—Water Service

The work of this Committee is highly technical and discourses upon the many details of appliances and methods have been given to the members for their use. Several of them have been written by members of the Committee as monographs, which are very valuable. The Committee does not contemplate the proposal of additions for the Manual, but is engaged upon the revision of the forms used by the Water Department, and certain of the definitions applying to water service work; and expects to prepare complete specifications for laying water pipe.

Committee XIV—Yards and Terminals

An important addition was made to the Manual by the study of "The Proper Width of Driveways for Team Tracks and for Freight Houses," and useful information on other subjects is under way.

The specifications for the manufacture and installation of Four-Section Knife Edge Railway Track Scales are the standard specifications for scales of this type throughout the United States. They had been published in pamphlet form, Circular No. 83, by the United States Bureau of Standards. It is believed that the specifications for the manufacture and installation of Two-Section Knife Edge Railway Track Scales and for the manufacture and installation of Motor Truck, Built-In, Self-Contained and Portable Scales for railway service will tend to approach similar recognition as they become more generally known. The rules for the location, maintenance, testing and operation of track scales are the basis for the adopted practice of various railways.

Numerous extensive and important investigations have been made by the Committee in connection with Passenger and Freight Terminals. Recommended practice in connection with these matters is not generally of a nature to permit of adoption in the same manner as specifications. They are, instead, a guide in the study of individual problems and in this respect are found of great value by the railways generally.

Committee XV—Iron and Steel Structures

Subjects of the greatest importance to our members are under study by this Committee, and naturally they are extremely technical, and require much research work, experimental, fundamental mechanical testing, and documentary evidence.

The subject-matter of the "Specifications for Steel Highway Bridges" compiled in conference with the American Association of State Highway Engineers is in the hands of the editing committee and will probably be submitted to the Thirtieth Annual Convention.

"Specifications for Steel Railway Bridges" are being developed in conference with committee members of the American Society of Civil Engineers, and have reached the point of completion of the preliminary work so that it is expected that presentation can be made in 1929 as information.

Committee XVI—Economics of Railway Location

The Committee does not expect to offer any change in recommended practices. It is gathering information on the relative merits of grade lines lighter than 0.4 per cent, and on economies of grade revision by the use of electric and more powerful steam locomotives.

Committee XVII—Wood Preservation

Extensive revisions of the Manual were adopted in 1927, and additional recommendations are under study in connection with "Piling Used for Marine Construction," concerning which much valuable information has been presented as the result of original research investigation, and service effect of different mixtures for preservative treatment. The continuing report upon "Service Test Records for Treated Ties" is always looked forward to by the members.

Committee XVIII—Electricity

This Committee is the Electrical Section of Division IV—Engineering of the American Railway Association, and for the most part submits its recommended practices to that body. Nevertheless some of its work is placed in the Manual and it expects to recommend for the Manual at the Thirtieth Annual Convention the revised "Incandescent Lamp Schedule" to take the place of that of 1926 rescinded at the Annual Convention of 1928.

Except in the above case, it is uncertain when the additional subjects of very great importance printed in Proceedings, A.R.E.A., Vol. 29, 1928, for membership study will be advanced for Manual acceptance. These are "Overhead Transmission Lines and Catenary Construction," "Specifications for Track and Third Rail Bonds," and "Design of Indoor and Outdoor Sub-Stations."

The Committee is engaged in co-operation with other interested societies and organizations in carrying along research work upon many problems of wide interest in the electrical field which have an important relationship with standardization. These are the:

- American Committee on Inductive Co-ordination.
- American Committee on Electrolysis.
- American Standards Association on National Electrical Safety Code.
- United States Department of Commerce, Bureau of Standards, on Simplified Practice Recommendation No. 73—One-Piece Porcelain Insulators.

In addition, the Committee keeps up to date information concerning the changes necessary in:

- Clearances for Third Rail and Overhead Working Conductors.
- Protection of Oil Sidings from Danger Due to Stray Currents.
- Progress in Water Power Development.

Its reported matter for 1928 required 100 pages.

Committee XX—Uniform General Contract Forms

The Committee has recently made important revisions in its recommended practice so as to have the new edition of the Manual as complete as possible, and has in preparation reports on forms of agreement for various uses which will be submitted to the members.

Committee XXI—Economics of Railway Operation

The work of studying the details of railway operations, the perfection or looseness of which writes plus or minus in the monthly financial statements of returns or deficits, is one of the most difficult tasks given by the Association Directorate. Each subject requires the profound consideration necessary for a thesis. Those now being worked out by the Committee for presentation to the members are of great importance. During the past year Committee has added to Manual formula and methods for computing costs of stopping and starting freight trains.

Committee XXII—Economics of Railway Labor

The subjects under consideration have not been developed to the point for submission to the Association. The employment and management of labor economically and successfully is of the very greatest importance in economical operation, and the subjects engaging attention for future reports were selected for pointing out important advancement possibilities.

Committee XXIII—Shops and Locomotive Terminals

The Committee is engaged in the study and preparation of recommendations for the consideration of the members, as was done in 1928 upon the subject of "Locomotive Coaling Stations," one of the workshops so necessary for the quick handling of motive power rolling stock. It will propose revisions of the safe and convenient storage of crude and fuel oil, and submit additional recommendations on sand facilities in connection with the report on coal chutes and sand plants.

Committee XXIV—Co-operative Relations with Universities

A work of study of such magnitude and importance, interlocking as it does with the basic principles of all education, cannot be dealt with except slowly, but substantial progress in co-ordination of thought is being made.

Special Committee on Stresses in Railroad Track

Such original, profound, and far-reaching research work has been done that the result of the latest track-joint survey by recording instruments is eagerly anticipated by the membership at the Thirtieth Annual Convention.

Special Committee on Standardization

This is a "Bureau of Record and Reporting" which hopes to keep its fellow-members informed upon the important progress of uniformity in railway practices, sectional, national and international.

Special Committee on Clearances

Co-ordination in this field is a work of patience and time which will be invaluable when completed.

Special Committee on Rivers and Harbors

The Committee, a new one, has not yet finished its investigations into the many important subjects submitted to it.

PART II—EXTENT OF USE OF "RECOMMENDED PRACTICES" BY ASSOCIATION MEMBERS

An effort has been made to add to the record of information on this subject printed in Proceedings, A.R.E.A., Vol. 29, 1928, pages 69 to 75, but that record stands yet as the most complete general knowledge that we have.

However, Mr. A. F. Blaess has prepared for the Illinois Central Railroad such a complete exposition of the extent of use of each one of the recommended practices of each separate committee that it will serve as a model for similar investigation by other companies. It is therefore printed as Appendix B.

There are three degrees of use for which the dogma of "Recommended Practice" are available, or adaptable for appropriation into one's own specifications or instructions:

1. Adoption verbatim, or nearly so, of the plans, specifications, instructions or rules.
2. Incorporation of the fundamental or main items of importance in settling upon and maintaining unification of methods.
3. Acceptance of the general influence of the data and citations in order that one's own practice may be in general accord.

The Illinois Central uses the work of the committees in all of these different ways, and the replies of other chairmen of committees indicate that it is the practice with the railways in general.

It may be looked upon as the part of good membership for any member to call attention to desirable changes in recommended practice which have been made evident by some special experience in the case of a problem or transaction, the investigation and study of which developed a lack of completeness or mistaken conclusion in the practice in vogue.

PART III—INDUSTRIAL-AND-ASSOCIATION MUTUAL AFFILIATIONS IN STANDARDIZATION

In the field of standardization in which lies the special work of the American Railway Engineering Association, our closest affiliations are with the American Society for Testing Materials, the Federal Specifications Board under the Chairmanship of the Bureau of Standards, the various Divisions of the American Railway Association, and the College Engineering Laboratories.

American Society for Testing Materials

The work of this society, representing as it does the avowed object of united "users" and "manufacturers" to place methods of testing in research work on a unified basis, is of great assistance to our Association, and all the more so by reason of the components of membership.

Its recommendations represent the union of minds of the manufacturers who make the materials, appliances, machines and articles, and of those who make use of them in the conduct of another business of service and provision for the comfort and happiness of the people, by providing descriptive notes or "specifications" of requirements for the articles, and the methods of proof-testing for certification of the accomplishment of the object.

Its work is participated in by assigned members from our several committees.

Its membership on June 1, 1928, was 4193, its regular publications number 3975 pages, and its expenditures last year were $150,000.

A very important enlargement of its activity was authorized by the Executive Committee this year by the formation of a Research Committee on Fatigue Phenomena in Metals, having the broad functions of conducting, correlating and summarizing research in fatigue of metals.

Federal Specifications Board

The unification in 1921 of the standardizing bodies of the multitudinous departments and bureaus of the United States Government by the Budget is a most admirable advance in administration, if this available instrument be used to the full extent of the good for which it is capable.

Its Chairman, the U.S. Bureau of Standards, may be considered to have three classes of activity and performance which are quite separate and distinct, but at the same time are to a certain extent interrelated:

(a) Studies embracing the highest degree of Pure Science.

(b) Laboratory Research Investigation in the field of Applied Science for establishing industrial and commercial standards.

(c) Elimination of Waste in Industry by reduction in the varieties of articles through the machinery of Simplification.

(a) "Pure Science" study is the natural outgrowth of the Bureau of Standards from its creation on March 3, 1901,[1] as the custodian of the standard weights and measures of the United States, for the maintenance of those standards requires the highest and most profound knowledge of mathematics and physics. Within the span of life of this Bureau, the marvelous development of the knowledge of electrical phenomena has occurred through pure science study, and pure science has no national boundaries. It is, too, the fundamental and main cause of the Bureau's existence. Such standardization work and duties can be performed only by a national government.

[2]Last year, 1927, was the fiftieth anniversary of the establishment of the International Bureau of Weights and Measures, the organization which keeps governmental national standards in known ratio with each other, and in commemoration of the event a special meeting was held under the auspices of the French Academy of Sciences.

As a result of this meeting, Dr. George K. Burgess, Director of the Bureau of Standards, addressed the following letter to the American Railway Association:

DEPARTMENT OF COMMERCE

BUREAU OF STANDARDS

Washington

Refer to File No. D
April 13, 1928.

American Railway Association,
30 Vesey Street,
New York, N. Y.

Gentlemen:

At the last meetings of the International Committee of Weights and Measures and the General Conference on Weights and Measures held in

[1] Proceedings American Railway Engineering Association, Vol. 28, 1927, p. 161.
[2] Bulletin American Railway Engineering Association, No. 300, October, 1927, p. 88.

Paris last September and October, the question of international agreement on the standard temperature for intercomparison of industrial standards of length, such as precision gage blocks and other end standards, graduated scales, lead screws, etc., was discussed, and there was set up a committee of five members to study this question and report before the first of March, 1929. The following are the members: Bureau of Standards, Washington; Laboratorie d'Essais due Conservatorie des Arts et Metiers, Paris; National Physical Laboratory, Teddington; Physikalischtechnische Reichsanstalt, Charlottenburg; with Director Guillaume of the International Bureau.

The American Delegates, supported by practically all the Europeans except the British and French, proposed 20 degrees C. (68 degrees F.), the British 62 degrees F. (16⅔ degrees C.), and in France I believe both 0 degrees C. (32 degrees F.) and 20 degrees C. (68 degrees F.) are in use.

It is considered desirable to get a consensus of opinion from the engineering and industrial activities of the various countries and with this object in view I am calling a conference at an early date at the Bureau of Standards and request your organization to designate a representative.

Yours very truly,

(s) GEORGE K. BURGESS, *Director.*

Upon recommendation by President Faucette, W. C. Cushing was appointed April 24, 1928, by President Aishton as the representative of the Association.

(b) and (c) The laboratories for Research Investigation for establishing industrial and commercial standards *for the use of the government agencies* correspond with the laboratories of the great industrial enterprises for the purpose of control and economy of manufacture and utility. The object is of as essential importance in the one case as the other, for knowledge of the strength and characteristics of materials of construction is necessary when preparing specifications for their purchases and use.

These laboratories have now been expanded to cover as well research investigation and establishment of commercial standards. The announcement was made in the Monthly News Bulletin of the Division of Simplified Practice, October 15, 1927, as follows:

> "In recognition of the request for co-operative service in this phase of the simplification program, the Department of Commerce announces through its Bureau of Standards that it is now prepared to aid those industrial and commercial groups desiring to establish standards of grade and quality for their products or their purchases, or to secure relief in instances where the current variety in grades, qualities, and specifications is a burden on the producer, and a handicap to the purchaser.
>
> "The Bureau's service in this direction includes a certificate and labeling plan wherein goods manufactured according to commercial standards approved by the Bureau, may be so labeled and certified to by the manufacturers. This affords a greater protection to the purchaser and at the same time strengthens the manufacturers' selling arguments.
>
> [1]"Groups desiring further information on this broadened service of the Bureau are invited to address R. M. Hudson, Assistant Director, Commercial Standards, Commerce Building, Pennsylvania Avenue and 19th Street, Washington, D. C."

[1]See Appendix D for important addition to this subject.

The first issue of the Monthly News Bulletin of the Commercial Standards Group of the Bureau of Standards, November 15, 1927, announces that it includes:

Division of Simplified Practice.
Division of Specifications.
Commercial Standards Unit.
American Marine Standards Committee.

The number of United States Government Master Specifications promulgated by the Federal Specifications Board is 547 up to January 1, 1928.[3]

American Railway Association

This is the official organization through which the railways are enabled to conduct their operations as a unit railway system in cases where their activities expand into national importance from their sectional routine. These major questions are:

Standard Time.
Standard Code of Train Rules.
Block Signal and Interlocking Signal Rules.
Car Service.
Codes of Transportation Rules (a dozen or more, including Track Scales).
Committee on Relations of Railway Operation to Legislation.
Bureau of Railway Economics.
Bureau for the Safe Transportation of Explosives and Other Dangerous Articles.
Railway Mail Pay.
General Dimensions of Rolling Stock.
Per Diem.
Demurrage.
Grade Crossing Safety.
Standard Dimensions of Box Cars.
Clearances.
Automatic Train Control.

Harmonizing general railroad practice in dealing with these problems of fundamental importance in the field of railroad transportation is essentially *standardization* work of widespread value.

In addition to this fundamental standardization, this Association, through the agency of its technical Divisions and Sections, of which the American Railway Engineering Association is one, is the *sponsor* of technical and manufacturing standardization of materials of construction appliances and articles so supremely necessary an adjunct in their intelligent purchase and effective application.

Research work has become a vital medium of investigation into economic management and consequent enlarged and improved production in all industrial affairs.

In forwarding this valuable work the American Railway Association provides the monetary sinews for the necessary research work in its successful solution. Its annual budget for special investigation is more than 1¼ million dollars.

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[3] Circular of the Bureau of Standards No. 319.

Since 1907, it has been financing the annual research work of Committee IV—Rail, amounting to about $10,000; for several years has been providing financial assistance, now amounting to $8000, to the Special Committee on Stresses in Railroad Track, and contributes $500 to Committee XXIV—Co-operative Relations with Universities.

Through the agency of Division VI—Purchases and Stores, as well as of Division IV—Engineering, it has been assisting in bringing to a successful consummation the Standardization of Classification of Lumber, and we transcribe herewith the report of the sub-committee on this subject to the Annual Meeting in June, 1928:

THE STANDARDIZATION OF LUMBER

"Each year since 1923 the reports on Subject 5 have placed in the Proceedings of the Purchases and Stores Division references to the simplification of lumber sizes and terms which has developed under the co-operative effort of manufacturers, distributors, and consumers into what are known as American Lumber Standards. In 1925 the Purchases and Stores Division adopted American Lumber Standards as they stood at that time, and in 1927 adopted the revision of sizes which had been made. In 1926 the Engineering Division adopted American Lumber Standards, and also provided coded specifications for structural grades.

"No organization has a clearer record for official approval of American Lumber Standards than the American Railway Association. At no time since the United States Departments of Agriculture and Commerce sponsored the work of eliminating the waste in lumber due to superfluous sizes has the American Railway Association been backward in supporting the effort. Yet because some railroads have not seen fit to accept as recommended practice certain alleged American Lumber Standards some lumbermen claim that the railroads are not co-operating. The misunderstandings of the facts on both sides of the question seem to warrant the following statement of the situation.

"American Lumber Standards classify the product of the sawmill and planing mill as (a) yard lumber, (b) structural timber, (c) factory or shop lumber. Since car lumber has not yet been given a class distinction, some of those in railroad organizations who should be acquainted with the subject seem to have overlooked the adoption by the American Railway Association of American Lumber Standards for lumber not used in cars. Complete appreciation of the fact and action accordingly would improve the lumber situation.

"The reports on Subject 5 for the past three years have stated that the Mechanical Division was working on sizes and grades for car lumber. Its Committee on Car Construction has striven to use standard yard sizes as far as possible. It is recommending this year the adoption as alternates of sizes which seem narrower in some widths than was formerly the case, but which differ because the Mechanical Division in 1926 adopted moisture contents lower than those understood to apply to commercially dry lumber. The Committee on Car Construction is recommending that during the ensuing year comparative prices be obtained on both sizes of car lumber, at the American Railway Association standard moisture contents, with a view of seeing what might be saved by the use of the proposed patterns, and the members of Division VI can help in getting this information.

"American Lumber Standards provide only basic grade description for the classes of material included. In adopting these basic provisions, the American Railway Association did not commit the railroads to any detailed grading rules which might be published by regional associations of lumber manufacturers. Railroads which find grading rules reputedly revised in accordance with American Lumber Standards resulting in higher costs, are not bound to such new rules. However, each railroad should not aim to have lumber grading rules of its own. Until the Committee on Specifications and Tests of Division V presents a report which is adopted, railroads should use for car lumber the grading rules adopted by the Master Car Builders' Association and the Railway Storekeepers' Association in 1910. For general building purposes the grading rules for yard lumber published by the regional lumber associations and endorsed as in accordance with American Lumber Standards provide material from which railroads should be able to select lumber suitable for any given purpose. For structural timbers the code approved by Division IV enables the Construction and Engineering Departments to tell the Purchasing and Stores Departments what is required.

"The fact that railroad buyers of forest products find some sellers of wood unfamiliar or unsympathetic with American Lumber Standards is no reason why the actions of Divisions IV, V and VI should not be made effective through purchasing American Lumber Standard grades and sizes as far as possible. The benefits of standardization will not be obtained until standard lumber is insisted upon wherever it can be used."

Sub-Committees are also at work on the Standardization of Stationery and Printing, and furnishing representatives to co-operate with the Division of Simplified Practice of the U.S. Department of Commerce in bringing about reduction in sizes, etc., of supplies, some of which are Handle Grading, Hack Saw Blades, etc.

The stamp of approval by the American Railway Association in the advancement of Standardization is a valuable asset in the conduct of the arduous and painstaking detail work required for successful consummation. A brief memorandum of its official organization follows:

R. H. Aishton, President, 431 South Dearborn Street, Chicago, Ill.
W. G. Besler, First Vice-President, Chairman of Board, Central Railroad of New Jersey, New York, N. Y.
Hale Holden, Second Vice-President, President, Chicago, Burlington & Quincy Railroad, Chicago, Ill.
Alfred P. Thom, General Counsel, 17th and H Streets, N. W., Washington, D. C.
H. J. Forster, Secretary and Treasurer, 30 Vesey Street, New York, N. Y.

BOARD OF DIRECTORS

W. W. Atterbury (President, Pennsylvania Railroad), Philadelphia, Pa.
L. W. Baldwin (President, Missouri Pacific Lines), St. Louis, Mo.
E. W. Beatty (President, Canadian Pacific Railway), Montreal, Que.
W. G. Besler (Chairman of Board, Central Railroad of New Jersey), New York, N. Y.
H. E. Byram (Chairman of Board, Chicago, Milwaukee, St. Paul & Pacific Railroad), Chicago, Ill.
W. R. Cole (President, Louisville & Nashville Railroad), Louisville, Ky.
P. E. Crowley (President, New York Central Lines), New York, N. Y.
J. M. Davis (President, Delaware Lackawanna & Western Railroad), New York, N. Y.
[1]Howard Elliott (Chairman, Northern Pacific Railway), New York, N. Y.
C. R. Gray (President, Union Pacific System), Omaha, Neb.
Fairfax Harrison (President, Southern Railway System), Washington, D. C.

[1]Deceased.

Hale Holden (President, Chicago, Burlington & Quincy Railroad), Chicago, Ill.
E. E. Loomis (President, Lehigh Valley Railroad), New York, N. Y.
A. D. McDonald (Vice-Chairman of Executive Committee, Southern Pacific Company), New York, N. Y.
C. H. Markham (Chairman of the Board, Illinois Central Railroad), Chicago, Ill.
A. C. Needles (President, Norfolk & Western Railway), Roanoke, Va.
[1]E. J. Pearson (President, New York, New Haven & Hartford Railroad), New Haven, Conn.
W. B. Storey (President, Atchison, Topeka & Santa Fe Railway), Chicago, Ill.
Sir H. W. Thornton, K. B. E. (Chairman of Board of Directors and President, Canadian National Railways), Montreal, Can.
Percy R. Todd (President, Boston & Albany Railroad), Bangor, Me.
Daniel Willard (President, Baltimore & Ohio Railroad), Baltimore, Md.
S. M. Felton, ex-officio (Chairman, Western Presidents' Conference Committee) (Chairman of Board, Chicago Great Western Railroad), Chicago, Ill.
L. F. Loree, ex-officio (Chairman, Eastern Presidents' Conference Committee) (President, Delaware & Hudson Company), New York, N. Y.

They meet quarterly in January, May, September and November.

The American Railway Association originated as Time Convention in Louisville, 1872.

Became General Time Convention, 1875.

Became American Railway Association, 1891.

Enlarged to take in independent technical railway associations 1919, as follows:

Master Car Builders' Assoc. } Taken in previously to 1919—date unknown.
Master Mechanics' Assoc. }
American Association of Freight Agents.
American Association of Railway Surgeons.
American Railway Perishable Freight Association.
Association of Railway Telegraph Superintendents.
Association of Transportation and Car Accounting Officers.
Freight Claim Association.
International Association of Railway Special Agents and Police.
Master Car and Locomotive Painters' Association.
Railway Signal Association.
Railway Storekeepers' Association.
Electrical Association.
American Railway Engineering Association under its own incorporation and organization, reporting its operations to the American Railway Association.

Standard time for the United States was established in 1883.

The work of the Association is done through eight divisions and several special committees:

Division I—Operating,
    Telegraph and Telephone Section,
    Protective Section,
    Medical and Surgical Section,
    Safety Section,
    Freight Station Section.

[1]Deceased.

Division II—Transportation.
Division III—Traffic.
Division IV—Engineering,

Construction and Maintenance Section (Amer. Ry. Engr. Assoc.),
Electrical Section,
Signal Section.

Division V—Mechanical.
Division VI—Purchases and Stores.
Division VII—Freight Claims.
Division VIII—Motor Transport.

College Engineering Laboratories

Besides its scope in the undergraduate curricula, the College Engineering Laboratory is an agency for promoting the graduate-student development of the engineer graduate, which he must seek to amplify during his entire professional career. It is a workshop for discovering the mechanics of materials with reference to motion, strength, elasticity and energy for the purpose of synthesizing principles of design and construction, of tool and machine creation.

These laboratories have been of especial value in assisting the members of this body to solve the problems of their several spheres of work. There is hardly a committee whose work is not participated in by their professorial representatives. Organized collegiate methods lift haphazard everyday guesswork to the upper level of systematic technical and experimental research; that is, standardization of methods and conduct of attack upon the problem.

PART IV—AMERICAN STANDARDS ASSOCIATION

The American Railway Association is one of the twenty-nine member bodies whose representatives form the American Standards Association. Each Member-Body is entitled to three *representatives,* and two *alternates* for each of the latter. The A.R.A. has at present one representative and two alternates, appointed from Division IV—Engineering. They are at present as follows:

Representative: W. C. Cushing, Engineer of Standards, The Pennsylvania Railroad, Room 607 Broad Street Station, Philadelphia, Pa.
Alternate: J. R. W. Ambrose, Chief Engineer, Toronto Terminals Railway, Toronto, Ontario, Canada.
Alternate: E. K. Post, Signal Engineer, The Pennsylvania Railroad, West Philadelphia, Pa.

The term of representation is for three years, commencing January 1st, 1928.

Mr. Cushing has also been the representative of the American Railway Association on the Executive Committee, but in the fall of 1928, the name was changed to American Standards Association, with changes in the Constitution explained further on.

Early in this year, William J. Serrill, Assistant General Manager, United Gas Improvement Company, of Philadelphia, succeeded C. E. Skinner as the Chairman of the A.E.S.C. and Cloyd M. Chapman, Engineering Specialist of New York City, representing the American Society of Mechanical Engineers, became Vice-Chairman.

[4]"Standardization is a co-operative undertaking. * * * It simplifies manufacturing processes; it stabilizes production and employment, since it makes it safe for the manufacturers to accumulate stock during periods of slack orders, which he cannot safely do with an unstandardized product; it broadens markets both for the producer and for the consumer; it lowers cost to the public by making mass production possible; it enables buyer and seller to speak the same language, and makes it possible to compel competitive sellers to do likewise; it reduces selling cost; it stimulates research and makes for the elimination of antiquated methods and products; and by concentration on essentials, and the consequent suppression of confusing elements intended merely for sales effect, it helps to base competition squarely upon efficiency in production and distribution and upon intrinsic merit of product."

We are not so sure that it will do all of these things. They are the aims of standardization, but it will require the establishment of experience to make them facts. They are generalizations at present as are many of the statements current upon the subject.

Nevertheless, we believe in standardization *rightly managed,* and its most important coadjutor is the agency for revision and its maintenance right up to date, or else it is soon ignored and forgotten. In this respect we believed there was room for improvement in the mechanism of the American Standards Association, some of which have been brought about.

A centralized co-ordinating body for a [5]"thousand trade associations, hundreds of technical societies and other associations, and numerous branches of the Federal, State and City Government, requires an adequate and active internal organization involving a considerable expenditure of money in order to make the work successful.

For the past three years the A.E.S.C. has found [6]"its resources entirely inadequate to carry on the work entailed in the demands of industry for increased standardization activities." This has led to the thought that perhaps those in charge of industrial development did not completely appreciate the value of the work being done, and accordingly a prolonged review of its accomplishments and study for revision of the Constitution with the object of engaging the favorable and active attention and assistance of leaders in industry. The revised edition was favorably acted upon by the A.E.S.C. Main Committee in meeting of June 14, 1928, and, as it has been approved in this form by the Member-Bodies, we are offering a complete copy for the information of our members:

[4] Year Book, American Engineering Standards Committee—1928, p. 9.
[5] Year Book, American Engineering Standards Committee—1928, p. 10.
[6] Year Book, American Engineering Standards Committee—1928, p. 20.

PROPOSED REVISION OF CONSTITUTION

AMERICAN STANDARDS ASSOCIATION

Successor to American Engineering Standards Committee

(Submitted for Ratification by Member-Bodies)

ARTICLE I

Name

Section C1. The name of this organization shall be the American Standards Association (A.S.A.).

ARTICLE II

Objects

The bodies associating themselves in accordance with this Constitution do so with the following objects:

Section C2. To provide systematic means by which organizations concerned with standardization work may co-operate in establishing American Standards in those fields in which engineering methods apply, to the end that duplication of work and the promulgation of conflicting standards may be avoided.

Section C3. To serve as a clearing house for information on standardization work in the United States and foreign countries.

Section C4. To further the standardization movement as a means of advancing national economy, and to promote a knowledge of, and the use of, approved American industrial and engineering standards, both in the United States and in foreign countries, but not to formulate standards.

Section C5. To act as the authoritative American channel in international co-operation in standardization work, except in those fields adequately provided for by existing international organizations.

ARTICLE III

Membership

Section C6. There shall be five classes of members, Member-Bodies, Honorary Members, Directors, Councilors, and Sustaining-Members, as defined in Sections C7, C8, C9, C10 and C11.

Section C7. Member-Bodies shall be organizations or groups of organizations of national scope, with which the ultimate general authority and responsibility for the policies and affairs of the Association shall lie.

Section C8. Honorary Members may be elected as provided in the By-Laws.

Section C9. Directors shall be members of the Board of Directors, as hereinafter provided.

Section C10. Councilors shall be members of the Standards Council, as hereinafter provided, upon which they shall be the representatives of the Member-Bodies appointing them.

Section C11. Sustaining-Members shall be organizations, companies, or individuals interested in the work of the Association and subscribing to its support, as provided in the By-Laws.

Section C12. Organizations or groups of organizations may be admitted as Member-Bodies by action of the Board of Directors, for which action a three-fourths vote of those present and voting shall be required.

Section C13. Each Member-Body shall pay annual dues as fixed by the By-Laws.

Section C14. Any Member-Body may terminate its membership upon notice in writing, provided its dues, including those for the current calendar half year, have been paid.

ARTICLE IV

Officers

Section C15. There shall be a President and a Vice-President, who shall perform the duties usual to these offices. They shall be elected by the Board of Directors, and not necessarily from the membership of the Board. They shall serve for one year, or until their successors are elected. They shall not serve in these respective offices for more than three consecutive terms.

Section C16. A Secretary, or other executive officers of the Association, who shall not be members either of the Board or of the Standards Council, shall be appointed by the Board of Directors.

ARTICLE V

Board of Directors

Section C17. The executive, financial and general administrative functions of the Association, but not the function of approving standards, shall be vested in a Board of Directors consisting of the President, the Vice-President, the Junior Past President and nine elected Directors.

Section C18. The elected Directors shall serve for a term of three years, or until their successors are elected. They shall be elected by the Board upon nominations by selected Member-Bodies, as provided in the By-Laws.

ARTICLE VI

Standards Council

Section C19. There shall be a Standards Council composed of not more than three representatives from each Member-Body, and ex-officio, of the President, Vice-President, and the Junior Past President of Association, and the two Junior Past Chairmen of the Council. Members of the Council shall be termed Councilors. They shall serve a term of three years, and they shall be eligible for reappointment. Member-Bodies may appoint regular alternates to their Councilors to act for them in case of absence or disability of the latter.

Section C20. The functions of the Council shall be to formulate rules for the development of standards and for the constitution of committees; to approve, on behalf of the Association, such standards as it may find to be supported by a consensus, affirmatively expressed, of those substantially concerned with the standard; but not to formulate standards.

ARTICLE VII

By-Laws

Section C21. By-Laws shall be adopted not in conflict with this Constitution.

Section C22. Amendments to the By-Laws fixing amounts of dues of Member-Bodies, and their method of payment, shall be pursuant to the methods provided for effecting amendments to this Constitution.

Section C23. The By-Laws proposed by the American Engineering Standards Committee in order to bring its administrative routine into conformity with this Constitution, and identified by the symbol MC 680, 1928, shall automatically become the By-Laws of the Association until amended in accordance with Section 81 thereof.

ARTICLE VIII

Amendments

Section C24. Amendments to this Constitution must be proposed in writing at least thirty days before the meeting of the Board of Directors at which they are to be voted upon, this vote to be upon the amendment as originally proposed or as further amended at the meeting. If approved by three-fourths of those present they shall be referred to the Member-Bodies and shall become operative only when they have been approved by three-fourths of the Member-Bodies.

ARTICLE IX

Transition Measures

Upon formal ratification of this revised Constitution by three-fourths of the Member-Bodies.

Section C25. The Chairman and Vice-Chairman of the American Engineering Standards Committee shall assume the titles of President and Vice-President, respectively, of the American Standards Association, during the remainder of their terms; and the Main Committee shall become "The Standards Council."

Section C26. Until such time as the first Board of Directors is organized, general administrative and financial matters shall continue in the hands of the Executive Committee as organized under the American Engineering Standards Committee.

Section C27. There shall be constituted an interim Organizing Committee, consisting of the President, the Vice-President, the two Junior Past Chairmen of the American Engineering Standards Committee and the Director of the Bureau of Standards, whose duty shall be to organize the first Board of Directors, and to provide for such other transition matters as are not clearly functions of the officers or of any other agencies of the organization.

Section C28. The Organizing Committee shall select nine Member-Bodies from each of which they shall request the appointment of a Director. The nine so appointed, together with the President, the Vice-President, and the Junior Past Chairman of the American Engineering Standards Committee, shall constitute the Board of Directors for the remainder of the current calendar year.

Section C29. The Organizing Committee shall provide for the determination, by lot or otherwise, of the terms of these nine Directors, three of which terms shall expire annually.

Section C30. This Article shall cease to be a part of this Constitution when the Board of Directors is called to order at its first meeting.

PROPOSED BY-LAWS

AMERICAN STANDARDS ASSOCIATION

(Presented for Information Only—And not for Action)

1. Membership and Dues

Section 11. Each Member-Body shall pay annual dues of $500 for each representative (Councilor) it has upon the Standards Council. Government Departments or Bureaus shall not be required to pay dues. Dues of

Member-Bodies shall be payable in advance for the half year periods beginning January 1st and July 1st. Dues of new Member-Bodies shall date from the time of notification of their election.

Section 12. Any Member-Body may increase the number of its Councilors up to the constitutional limit of three, upon approval by the Board of Directors by a three-fourths vote of those present and voting.

Section 13. The election of Honorary Members shall be by the Board of Directors, for which a unanimous vote shall be required.

Section 14. Sustaining-Members shall be entitled to all regular publications of the Association. They shall be rendered an information service in regard to the work of the Association and data available to it; and they shall have free access to the records of the Association.

Section 15. The following schedule shall be recommended to prospective Sustaining-Members as appropriate subscriptions:

Gross Receipts (Total Annual Business) Millions of Dollars	*Recommended Subscription*
0-2	$ 25
2-4	50
4-6	75
6-10	100
10-15	150
15-20	200
20-30	300
30-50	500
50-75	750
75-100	1,000
100-150	1,500
150-200	2,000
200-250	2,500
250-300	3,000
300-400	4,000
Over 400	Proportionally

For firms preferring to subscribe on the basis of capital, rather than gross receipts, the recommended basis shall be one and one-half cents per thousand dollars of aggregate market value of the corporate securities of the firm, with a minimum of $25. In each case the determination of the amount above this minimum will, however, be left to the Sustaining-Member.

2. Administrative Year

Section 21. The administrative and fiscal year of the Association shall be the calendar year.

3. Meetings

Section 31. Unless the Board shall otherwise direct regular meetings of the Board of Directors shall be held in March, June, October and December of each year.

Section 32. Special meetings of the Board may be called by the President, or by three members of the Board.

Section 33. Unless the Council shall otherwise direct, regular meetings of the Standards Council shall be held in May and December.

Section 34. Special meetings of the Standards Council may be called by the President, or shall be called by the Secretary upon request of five Councilors.

Section 35. The December meeting shall be a joint meeting of the Board and the Council, at which Honorary Members and Sustaining-

Members may be present, and shall have the privileges of the floor (but not of voting), and at which the President, as Chairman of the Board, and the Chairman of the Council will report accomplishments and plans.

4. Elections

Section 41. Not later than August 1st of each year the Standards Council shall select from among the Member-Bodies six Member-Bodies which shall be eligible to make nominations for the three approaching vacancies on the Board of Directors. From these six, the Board shall select three Member-Bodies from which it shall invite nominations to fill the approaching vacancies on the Board.

5. Standing Committees

Section 51. A standing committee on Procedure shall be appointed by the Standards Council, and shall consist of at least three Councilors to serve for one year or until their successors are appointed.

Section 52. The Board of Directors may appoint other standing committees as it may deem desirable, such as Finance and Representation, whose functions shall be determined by the Board.

6. Approval of Standards

Section 61. The Standards Council shall have jurisdiction over the determination of the type of procedure to be followed in the development of standards, the assignment of sponsorships, and the approval of the personnel of sectional committees. The Council may delegate these functions to boards or committees.

Section 62. The approval of standards shall be by letter-ballot of the Standards Council. Such letter-ballots shall provide only for "Yes," or "No," votes and they shall be signed by the Councilor voting. In connection with the letter-ballot there shall be mailed to the Councilors a brief outline of the history of the development of the standard, and of the evidence of its acceptability to the groups concerned. All records shall be available for examination by any Councilor or Director.

Section 63. Letter-ballots on the approval of standards may be ordered by the Standards Council in session, or by the President upon the recommendation of boards or committees authorized by the Council to serve in an advisory capacity for this purpose.

Section 64. The approval of a standard may be withdrawn by letter-ballot of the Standards Council as in the case of the approval of a standard.

Section 65. The majority of the Standards Council required for action by letter-ballot on a standard shall be:

For approval as "American Standard"	90%
For approval as "American Tentative Standard" or as "American Recommended Practice"	75%
For withdrawal of approval	50%

Section 66. The vote shall be counted by the Secretary, who upon receipt of the deciding ballot shall certify the results, and shall notify all interested parties. The date of approval of a standard shall be the date of the certification of the results of the ballot.

7. Secretary

Section 71. A Secretary shall be appointed for the fiscal year by the Board of Directors which shall determine his salary. He shall devote his full time to the affairs of the Association unless otherwise authorized by the Board. He shall furnish a suitable bond, the cost of which shall be paid by the Association.

Section 72. The Secretary shall certify the accuracy of, and authorization for, all bills and vouchers upon which money is to be paid. He shall sign all checks, which shall then be countersigned by the President or Vice-President. He shall collect all moneys due the Association and deposit or invest its funds as instructed by the Board of Directors, and shall have charge of the books and accounts.

Section 73. The Secretary, or other designated officer, shall attend all the meetings of the Board of Directors and/or of the Standards Council, and shall record their proceedings. He may take part in the deliberations of these meetings but shall have no vote.

Section 74. The Secretary shall, with the approval of the Board of Directors, engage such technical and clerical staff as may be required, and he shall be responsible for the work of such employees.

8. Amendments

Section 81. Amendments to these By-Laws may be proposed in writing at any meeting of the Board of Directors. They shall become operative upon affirmative vote of three-fourths of the Board, except that for matters affecting the work and procedure of the Standards Council concurrence by at least two-thirds of the Council membership shall be required.

The prior Chairman of the A.E.S.C., Mr. Skinner, had already accomplished a great deal in the way of making the importance of the work better understood by officers of industry, and, therefore, the following reproduction from the Year Book of 1928 is significant:

"FOREWORD"

"The industrial standardization movement is an important factor in our industrial progress. Its influence touches all industry and commerce. Hence it merits the attention of every industrial executive.

"Industrial standardization is making many of the economies of mass production available to all manufacturers of essential commodities, large and small. It is improving processes and products, broadening markets, and aiding distribution and purchase. These constructive influences are extending to the field of foreign trade.

"That standardization is acting to promote a wholesome spirit of co-operation in industry is demonstrated by the work of the American Engineering Standards Committee. The three hundred national organizations and two thousand individuals engaged in the committee's activities prove that widely divergent interests can meet on a common ground. These results constitute one of the most notable examples we have of the possibilities of the movement for self-government in industry through co-operative effort."

J. A. Farrell, *Chairman,*
Advisory Committee of Industrial Executives.

Besides re-casting the Constitution, it was considered of the first importance and necessity to reform from within its own methods and machinery for carrying on its co-ordinating work of harmonizing and unifying standards for national use. The principal reformation brought about is given in the first page of the "Procedure," which is, therefore, repeated in full:

PROCEDURE[7]

Revised to March 8, 1928

1. General

101. A national standard implies a consensus of those substantially concerned with its scope and provisions. A chief function of the American Engineering Standards Committee is the judicial one of determining whether a national consensus has been reached. To provide flexibility in meeting the variety of conditions which obtain in standardization work, several alternative methods are provided. The basic test to be applied in all cases is the fact of the assent, affirmatively expressed, of the groups having substantial interest in the standard. Such groups have an inherent right to representation on the body dealing with the subject-matter of the standard, but it is not essential that this right be exercised.

102. Standards may come before the American Engineering Standards Committee for approval by any method that provides compliance with the requirements in Section 101; the following methods are recognized.

(a) *Sectional Committee Method*

This method consists in the formation at the beginning of a project, of a committee to make a standard, or many standards under an assigned scope, which is composed of representatives accredited for the purpose by the various organized groups concerned with the project.

Sectional committees may be established under two systems of administrative control, as follows:

(I) Under the administrative support and direction of one or more of the bodies principally concerned. Such bodies are known as Sponsors.

(II) They may function autonomously with certain limitations.

(b) *Existing Standards Method*

Existing standards may be approved by the Committee, provided it is shown that the standard is supported by a consensus of those substantially concerned with its scope and provisions.

(c) *Proprietary Standards Method*

A proprietary standard is defined as one made under the auspices of an organization occupying an outstanding position in the field of the standard and where the formulation of the standards, in the first instance and in its revisions, is done within the organization. Standards of this type may be approved by the Committee when it is shown that they are supported by a consensus of those substantially concerned with their scope and provisions.

(d) *General Acceptance Method*

This method consists in the establishment of the necessary consensus by a canvass, ordinarily by correspondence of those substantially concerned with the scope and provisions of the proposed standard.

103. To safeguard the judicial character of its approval, the Committee requires that projects coming before it for consideration be sponsored by one or more bodies competent to vouch for the technical qualifications of a standard.

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[7] Year Book—American Engineering Standards Committee—1928, p. 68.

A Sponsor is such a body recognized by the Committee as an advocate of a standard or a group of standards.

(a) An Administrative Sponsor is one which exercises administrative support and control over a Sectional committee.

(b) An Endorsing Sponsor is one which recommends entering upon, and/or the final endorsement of, a project assigned to an Autonomous Sectional committee or a project undertaken by the General Acceptance Method.

(c) A Proprietary Sponsor is one which produces proprietary standards within its own organization.

104. A Sponsor need not be a member-body. Two or more bodies may be designated as Joint Sponsors.

105. Administrative or Proprietary Sponsorships entail the responsibility, on behalf of the committees engaged in making standards, of:

(a) Causing the work to be prosecuted with due diligence.

(b) Providing for the publication of Standards.

(c) Providing for the administrative work and the facilities necessary thereto including secretarial service.

106. Administrative and Proprietary Sponsors shall keep the Committee advised of the progress of the work by means of quarterly reports or suitable and adequate general statements rendered in place of quarterly reports. The spirit of this requirement will be met if the Committee is kept suitably advised not only of the matters within its actual jurisdiction, but also upon matters relating to the work that are of general interest or concerning which it may be expected to receive enquiries.

107. Sponsorship assignments are subject to review by the Committee which, upon cause being shown, may revoke or change Sponsorship for any project.

108. The requirements established by the Committee for Sponsors apply to Administrative Sponsors in their capacity as Sponsors for Standards being made by the Sectional Committee Method, and they apply to Proprietary Sponsors so far as these Sponsors have offered their Proprietary Standards for the recognition and approval of the Committee. Equivalent requirements where applicable, exist for the officers of autonomous Representational Committees and Conferences functioning under the General Acceptance Method.

* * * * * *

[1]These reforms have been accomplished only by prolonged, tedious, patient, and very hard work on the part of the Rules Committee.

During the year 29 new standards have been approved, and 54 new projects initiated, bringing the total up to 275 already approved, or on which work is under way. The standards approved to May 1st, 1928, number 111, and are listed for the information of members as Appendix A.

The American Railway Engineering Association has not requested, during the past year, official approval as national standards of any of its recommended practices.

The names of Standing Committeemen of the American Railway Engineering Association who are serving as members of Sectional Committees of the American Standards Association, and in other co-operating societies are submitted for information in the tabulation following:

[1]For additional important statement see Appendix C.

Members of the A.R.E.A. Standing Committees Serving as Members of American Standards Association's Sectional Committees and on Committees of Co-Operating Societies

No. of Committee and Name of Member	American Standards Assn. Project	Co-operating Societies
I—Roadway W. C. Swartout	G 8—Zinc Coating of Iron and Steel, Specifications for; (fencing material).	ASTM—Comm. A-5 on Corrosion of Iron and Steel; Sub-Comm. IX, Metal Culvert Tests.
II—Ballast Stanton Walker		Director Engineering and Research Division—National Sand & Gravel Association.
III—Ties John Foley		U. S. Dept. of Commerce — Executive Comm. of National Committee on Wood Utilization.
		U. S. Dept. of Commerce — Consulting Committee on Lumber Standards.
		ARA—Div. VI, Purchases and Stores—Comm. on Forest Products.
		National Forestry Program Committee.
IV—Rail Earl Stimson		ASCE Joint Special Comm. on Stresses in Track with A.R.E.A.
E. E. Adams	B 18—Bolt, Nut and Rivet Proportions (B 18d—Track Bolts and Nuts, Sub-Comm. IV).	
F. L. C. Bond		Canadian Engineering Standards Association.
E. E. Chapman		ASTM—Comm. A-1 on Steel; Sub-Comm. VII—Rolled Steel Wheels and Steel Tires; Sub-Comm. VIII—Steel Castings; Sub-Comm. XI—Boiler Steel; Sub-Comm. XX — Plate Tolerances.
		ASTM—Committee A-2 on Wrought Iron.
		ASTM—Comm. A-3 on Cast Iron.
		ASTM—Comm. A-7 on Malleable Castings.
		ASTM—Comm. B-2 on Non-Ferrous Metal and Alloys.
		ASTM—Comm. D-11 on Rubber Products.
W. C. Cushing	Representative of A.R.A. Div. IV — Engineering, on "Main" and "Executive" Committees.	ASTM—Comm. A-1 on Steel; Sub-Comm. 1—Steel Rail and Accessories.
		ASCE — Joint Special Comm. Stresses in Track, with A.R.E.A.

No. of Committee and Name of Member	American Standards Assn. Project	Co-operating Societies
J. M. R. Fairbairn		Canadian Engineering Standards Association.
C. R. Harding (also V—Track).		ASCE—Joint Comm. on Specifications for Steel Ry. Bridges, with A.R.E.A.
G. J. Ray		ASCE—Director, Joint Special Committee on Stresses in Track, with A.R.E.A.
C. P. VanGundy	G 8—Zinc Coating of Iron and Steel, Specifications for.	ASTM—Comm. A-1 on Steel; Sub-Comm. XII—Methods of Chemical Analysis; Sub-Comm. XX — Plate Tolerances. Comm. A-2 on Wrought Iron. Comm. D-1 on Preservative Coatings for Structural Materials. Comm. D-2 on Petroleum Products and Lubricants (Honorary Chairman).
F. M. Waring		ASTM—Comm. A-1 on Steel; Advisory; Sub-Comm. IV—Spring Steel and Steel Springs; Sub-Comm. VI—Steel Forgings and Billets; Sub-Comm. VII — Rolled Steel Wheels and Steel Tires; Sub-Comm. VIII—Steel Castings; Sub-Comm. IX—Steel Tubing and Pipe; Sub-Comm. X—Boiler Steel; Sub-Comm. XV—Commercial Bar Steels; Sub-Comm. XXI—Steel for Welding. Comm. A-2 on Wrought Iron. Comm. E-1 on Methods of Testing. Comm. E-4 on Metallography. Comm. XX—Plate Appliances.
J. B. Young		ASTM—Comm. A-1 on Steel (Chairman); Sub-Comm. I—Steel Rail and Accessories; Sub-Comm. VI—Steel Forgings and Billets; Sub-Comm. VIII—Steel Castings; Sub- Comm.XI—Boiler Steel; Sub-Comm. XVIII—Nomenclature and Definitions.
		ASTM—Committee A-2 on Wrought Iron.
		ASTM—Comm. A-3 on Cast Iron.
		ASTM—Comm. D-1 on Preservative Coatings for Structural Materials.
		ASTM—Comm. E-5 on Standing Committees.

No. of Committee and Name of Member	American Standards Assn. Project	Co-operating Societies
V—Track		
J. V. Neubert	B 18—Bolt, Nut and Rivet Proportions (B 18d—Track Bolts and Nuts, Sub-Comm. IV.)	Roadmasters and M. of W. Assoc.
VII—Buildings		
A. C. Irwin		Am. Ry. Brdg. and Building Assoc. (Joint Comm.)
G. A. Rodman		Am. Ry. Brdg. and Building Assoc. Comm. on Painting of Railway Buildings. Comm. on Subjects. Comm. on Arrangements.
A. T. Upson	A 14—1923—Ladders, Safety Code for O 4—1927—Wood, Methods of Testing. O 1—1924—Woodworking Plants, Safety Code for.	ASTM Comm. D-7 on Timber, U. S. Dept. of Commerce, Central Comm. on Lumber Standards (Secretary).
VII—Wooden Bridges and Trestles		
W. E. Hawley		U. S. Dept. of Commerce, Central Committee on Lumber Standards.
VIII—Masonry		
J. F. Leonard		ASTM Comm. C-1 on Cement; Sub-Comm. VII—Strength.
J. J. Yates		ASTM Comm. C-1 on Cement; Sub-Comm. XI—Sea Water Cements.
IX—Grade Crossings		
Maro Johnson	G 8—Zinc Coating of Iron and Steel, Specifications for.	ASTM Comm. A-5 on Corrosion of Iron and Steel. Sub-Comm. VIII—Field Tests of Metallic Coatings.
W. J. Towne		ARA—Chairman, Comm. Grade Crossing Protection and Trespassing.
A. C. Mackenzie		Canadian Engineering Standards Association—Committee on Traffic Signals for Highways.
X—Signals and Interlocking		
A. H. Rudd	D 5—Street Traffic Signs, Signals and Markings, Code for.	
W. J. Eck	D 5—Street Traffic Signs, Signals and Markings, Code for (Alternate).	
E. G. Stradling	C 8—Wires and Cables, Insulated (other than Telephone and Telegraph). Representative. Tech. Comm. No. 7 Magnet Wire. Tech. Comm. No. 12 Weatherproof, Heat-resisting and Similar Wires and Cables.	
W. H. Elliott	C 8—Wires and Cables, Insulated (other than Telephone and Telegraph). Representative.	

No. of Committee and Name of Member	American Standards Assn. Project	Co-operating Societies
XIII—Water Service		
C. R. Knowles	B 16—Pipe Flanges and Fittings (B 16j—Malleable Iron Brass Seat Unions for High Pressures). A 21—Pipe, Cast Iron and Special Castings, Specifications for.	
J. J. Laudig	B 36—Dimensions and Materials of Wrought Iron and Wrought Steel Pipe and Tubing, Stndardization of.	
XIV—Yards and Terminals		
J. R. W. Ambrose	Alternate Representative of A.R.A., Div. IV—Engineering.	
J. E. Armstrong		Canadian Engineering Standards Association.
C. H. Crawford		Amer. Soc. Mech. Engineers—Comm. of Metropolitan Section.
A. W. Epright		ARA — Comm. on Weighing and Inspection of Freight Traffic. Grain Conference Comm.
H. L. Ripley	A 34—Manhole Frames and Covers.	
C. U. Smith		Am. Ry. Brdg. and Building Assoc. Comm. on Construction and Placing of Concrete Unit-Built Slabs.
E. E. R. Tratman		Am. Ry. Brdg. and Building Assoc. Comm. on Precast Concrete Slab Construction.
I. D. Waterman		ASTM—Comm. A-5 on Corrosion of Iron and Steel, Representing A.R.E.A. Sub-Comm. VI — Specifications for Metallic Coated Products.
XV—Iron and Steel Structures		
O. F. Dalstrom, Ch. O. E. Selby I. L. Simmons F. E. Turneaure	A 3a—Bridges, Steel Railway, General Specifications.	
J. B. Hunley, Ch. A. Reichmann O. E. Selby	A 34—Bridge Superstructure, Steel Highway, Specifications for Design and Construction of.	
XVI—Economics of Ry. Location	None.	None
XVII—Wood Preservation		
H. von Schrenk	O 5—Poles, Wood, Specifications for.	ASTM—Comm. D-7 on Timber (Chairman).
E. B. Fulks		ASTM—Comm. D-7 on Timber. Sub-Comm. XI — Moisture Content of Timber. Sub-Comm. VI—Timber Preservatives.

No. of Committee and Name of Member	American Standards Assn. Project	Co-operating Societies
XVIII—Electricity		
L. S. Billeau	C 8—Wires and Cables, Insulated (other than Telephone and Telegraph). C 8e—Standard Make-ups for Rubber Insulated Wires. Tech. Comm. No. 10 (Alt. Representative Assoc. Ry. Elec. Engineers). C 8k—Weatherproof, Heat Resisting and Similar Wires. Tech. Comm. No. 12.	Association Railway Electric Engineers—Committee on Illumination.
H. A. Currie	Standards for Direct Current Generators and Motors (A.I.E.E.)	
J. C. Davidson		American Elec. Ry. Assoc.—Comm. on Heavy Electric Traction.
J. H. Davis		American Elec. Ry. Assoc.—Comm. on Heavy Electric Traction.
C. L. Doub		American Elec. Ry. Assoc.—Power Special Comm. No. 2 on Mercury Arc Rectifiers.
J. V. B. Duer		American Elec. Ry. Assoc.—Comm. on Heavy Electric Traction.
J. S. Hagan		A.I.E.E.—Comm. on Protection Devices.
F. D. Hall	C 29 — Power Line Insulators for Voltages Exceeding 750. C 20—Line Insulators for Voltages not Exceeding 750.	
C. B. Martin	C 8—Wires and Cables, Insulated (other than Telephone and Telegraph.)	ASTM—Comm. D-11 on Rubber Products.
W. L. Morse	C 2—1927 — Electrical Safety Code (National Electrical Safety Code) 1922 Revision of Parts 2 and 4.	
R. J. Needham	A 36—Rating of Rivers.	
W. M. Vandersluis		U. S. National Comm. International Electro-Technical Commission. Comm. of Advisors on Rules and Regulations for Overhead Lines.
L. S. Wells	C 2—1927 — Electrical Safety Code (National Electrical Safety Code), 1922 Revision of Parts 1 and 3 and Sec. 9. C 8—Wires and Cables, Insulated (other than Telephone and Telegraph), Sub-Comm. Railway Equipment. C 8h—Fibrous Coverings. C 8k—Weatherproof, Heat Resisting and Similar Wires.	
L. C. Winship		American Elec. Ry. Assoc.—Comm. on Heavy Electric Traction.
G. I. Wright		American Elec. Ry. Assoc.—Comm. on Heavy Electric Traction.

No. of Committee and Name of Members	American Standards Assn. Project	Co-operating Societies
C. G. Winslow	C 26—Fractional Horse Power Motors, Direct and Alternating Current, Standards for.	
Sidney Withington	C 25—Induction Motors and Induction Machines in General, Standards for.	Nat. Elec. Light Assoc.—Comm. on Electrification of Steam Railroads.
	Electrical Advisory Comm.	AIEE—Comm. on Transportation Comm. No. 42, Recommendation for International Standards on Ry. Motors.
	C 8—Wires and Cables, Insulated (other than Telephone and Telegraph.)	
	C 8f—Impregnated Paper Cable Tech. Comm. No. 5.	U. S. National Comm. International Electro-Technical Commission. Comm. of Advisors on Traction Motors.
	C 8k—Weatherproof, Heat Resisting and Similar Wires. Tech. Comm. No. 12.	
XXII—Economics of Ry. Labor		
T. S. Bond		ASCE.
H. A. Cassil		Am. Wood Preservers Assoc.
C. C. Cook		Am. Wood Preservers Assoc., 2nd Vice-Pres.
John Evans		ASCE.
E. T. Howson		ASCE.
		ASTM.
		Roadmasters and M. of W. Assoc.
		Railroad Bridge and Building Assoc.
F. J. Meyer		Roadmasters and M. of W. Assoc.
G. M. O'Rourke		ASCE.
A. N. Reece		ASCE.
		ASTM.
		Am. Wood Preservers Assoc., Sub-Comm. Member.
F. S. Schwinn		ASCE.
W. H. Vance		ASCE.
Special Comm. on Rivers and Harbors	None.	None.

One of the important "projects" under the auspices of the American Standards Association is the program of unification of the "Scientific and Engineering Symbols and Abbreviations," "Z 10," used in engineering and industry. The first step has been accomplished by the approval of those which include arithmetic and algebra, elementary geometry, analytic geometry, trigonometric and hyperbolic functions, calculus, special functions, and vector analysis. The effort was made to select from symbols already in use those which are most clearly understood and least likely to lead to confusion with other symbols.

The Sponsor Bodies are:

American Association for the Advancement of Science.
American Institute of Electrical Engineers.
American Society of Civil Engineers.
Society for the Promotion of Engineering Education.
The American Society of Mechanical Engineers.

Officers of Sectional Committee are:

Chairman—J. Franklin Meyer, Bureau of Standards, Washington, D. C.

Vice-Chairman—Sanford A. Moss, Thomson Research Laboratory, General Electric Company, West Lynn, Mass.

The Sub-Committee, No. 6, which prepared this first part Z 10f, is headed by:

Chairman—E. V. Huntington, Professor of Mechanics, Harvard University, Cambridge, Mass. (Representing American Mathematical Society.)

It has been printed, and is priced at 30 cents.

Other sub-committees are at work on symbols for hydraulics, heat and thermodynamics, aeronautics, navigation and topography, electrotechnical symbols (including radio), photometry and illumination, mechanics, structural engineering and testing materials.

Anyone who has attempted to consult a mathematical text book other than the one he used at school or college will be highly pleased at this undertaking.

The American Institute of Electrical Engineers has decided to refer all existing A.I.E.E. standards for approval by the A.S.A. as American Standards, except, of course, those previously submitted.

PART V—INTERNATIONAL STANDARDIZATION

In April, 1926, in New York, a conference of British and European representatives of national standardizing bodies was held with the American Engineering Standards Committee, as a result of which a Committee of seven, of which C. E. Skinner, Chairman, A.E.S.C., was a member, was appointed to meet in London and draw up the proposed Statutes and By-Laws for the International Standards Association (I.S.A.). This was done, and, as the subsequent events have been so well summarized in the Annual Report of the Executive Committee of the American Society for Testing Materials for presentation at the Thirty-first Annual Meeting held in Atlantic City, June 25th to 29th, 1928, we quote from it as follows:

"Concurrent with this proposal, and in fact growing out of it, was a proposal that the International Electrotechnical Commission might be suitably expanded to function internationally in engineering standardization along lines that it has pursued in the field of electrical standardization. Involved in these two proposals was the suggestion that the interests of the American Engineering Standards Committee and the U.S. National Committee of the I.E.C. in international technical matters might be suitably consolidated for the purpose of American representation in whatever international standardization body might ultimately be set up. A plan for expanding the U.S. National Committee of the I.E.C. had been proposed.

"Consideration of these matters has gone forward during the year, with which the Society has been in more or less close touch. Two developments may be recorded: First, it has been agreed that the International Electrotechnical Commission will not expand its field and will continue its standardization activities in electrotechnical matters, in which it is recognized as the authoritative international body. It will co-operate where necessary with other international bodies dealing with standardization matters. The proposed expansion of the U.S. National Committee of the I.E.C. has not been further considered. Secondly, the interim international committee formed to bring about the formal organization of an International Federation of National Standardizing Associations (I.S.A.), along the general lines originally contemplated and mentioned in last year's report, has formally laid the articles of constitution and a plan for preliminary organization before the national standardizing bodies of the world. Up to June 1, eleven of these national standardizing bodies (principally among the continental European nations) had indicated their willingness to become members of the I.S.A. The American Engineering Standards Committee has not yet made a decision, and the Executive Committee is informed that the British Engineering Standards Association has decided that it will be unable to become a member of the I.S.A. The withdrawal of the British, from whom the original suggestion for the formal international federation had emanated, has left the present status of this movement somewhat in doubt. Recent advices indicate that consideration is being given by the countries of continental Europe to an organization of less formal character.

"Pending further development and formation of suitable agencies for bringing about international co-operation in standardization activities, the Executive Committee will handle matters relating to international discussion of materials standards through whatever channels seem best suited to the purpose. In matters of general standardization, the Society looks to the American Engineering Standards Committee as a clearing-house, since that committee is in formal touch with the national standardizing bodies of the world. It is believed that the New International Association for the Testing of Materials is a logical medium for the international consideration of tests and properties of materials."

PART VI—THE BUSINESS OF NATIONAL STANDARDIZATION

The Chamber of Commerce of the United States passed the following resolution at its annual meeting in 1920:

> "The very essence of civilization is that there be placed upon the individual only that degree of restraint which shall vent his encroachment upon the rights of others, thus releasing to the utmost individual initiative in every proper direction.
>
> "Our form of government most effectively expresses and maintains this principle. Within our basic law exists ample provision for such changes as may from time to time be necessary to safeguard our people. It is, therefore, essential that our government should scrupulously refrain from entering any of the fields of transportation, communication, industry, and commerce, or any phase of business, when it can be successfully undertaken and conducted by private enterprise. Any tendency of government to enter such fields should be carefully weighed in the light of its possible effect upon the very genius of our institutions.

"There has been no better expression of this principle than is contained in this address of President Coolidge before the Daughters of the American Revolution Convention in Washington, D. C., April 16, 1928."

* * * * * *

Indeed this address of President Coolidge's is so clear, forceful, and remarkable an analysis of the established plan of governmental relation with business of an independent, forceful and vigorous people that long quotations from it are submitted herewith. It is evident that the President considered this warning was necessary at this present time in view of the express efforts of many Congressmen to unload various projects upon the Federal Government which are really the initiation of Government ownership and management, for over one-half of the address is occupied with the necessity for keeping the Government out of business:

"We do not grasp the full import of the American Revolution unless we consider it in its double aspect. In the first place, it was a struggle for independence. But the victory which, after long years of sacrifice crowned that effort, gave to the Colonies little more than an opportunity. They soon found that independence of the Crown of England was of small import unless they could establish themselves under a national government of their own. In the second place, therefore, the Revolution meant the adoption of the Federal Constitution. The war would have been of little value if the peace had not been used to create a nation.

"Prior to this period our institutions had been in the making, public opinion had been shaping. It was then that final decisions were made and the definite form of our fundamental law was declared. From time to time it has been broadened and strengthened, but in its main principles it has not been much changed. The Republic which it created is the Republic under which we live.

* * * * * *

"What they were contending for was primarily the rights of the individual, the security of life, of liberty, and of property. They wished him to be provided with an assurance of justice near his own home and to be protected from all unreasonable impositions by the hand of authority. They sought to make him free to manage his own affairs, whether they were economic, political, or religious. This was the heaviest responsibility that was ever undertaken by any people in the world.

* * * * * *

"Sometimes they have been tempted by specious presentations to believe that in some way they could live off the Government and get something for nothing, without having to make compensation through their labor or their loss of freedom.

"It is the righteous duty of society to assist the disproportionately weak and afflicted. This is the meaning of charity. The same duty requires the protection of the individual against crime and wrongdoing. That is the meaning of security. But the average run of the people must be personally responsible for their own affairs and their own success. Under our institutions they cannot evade this duty by attempting to shift it upon the Government, for they are themselves the Government. Unless they discharge this obligation themselves, there is no one that can discharge it for them. To attempt any other method is to deny that the principle of freedom, equality, and self-government is sound.

"If the American Revolution had one note that was more dominant than another, it was the principle that the people were competent to run their own business and manage their own government.

* * * * * *

"There are always those who are willing to surrender local self-government and turn over their affairs to some national authority in exchange for a payment of money out of the Federal Treasury. Whenever they find that some abuse needs correction in their neighborhood, instead of applying a remedy themselves they seek to have a tribunal sent on from Washington to discharge their duties for them, regardless of the fact that in accepting such supervision they are bartering away their freedom.

* * * * * *

"We have built our institutions around the rights of the individual. We believe he will be better off if he looks after himself. We believe that the municipality, the State, and the Nation will each be better off if they look after themselves. We do not know of any other theory that harmonizes with our conception of true manhood and true womanhood.

* * * * * *

"Our country to some extent tends to depart from these ideals. We are especially prone to call on the National Government to take over our burdens, and with them our freedom. Through regulations and commissions we have given the most arbitrary authority over our actions and our property into the hands of a few men.

* * * * * *

"There is one field, however, which belongs to the people, upon which they have uniformly insisted that the Federal Government should not trespass. That is the domain of private business. Society requires certain public activities, like highways and drainage, which are used in common and can best be provided by the Government. But in general the country is best served through the competition of private enterprise. If the people are to remain politically free, they must be economically free. Their only hope in that direction is for them to keep their own business in their own hands.

"Our theory of society rests on a higher level than communism. We want the people to be the owners of their property in their own right. We recognize that they are all capitalists by nature. We want them to be all capitalists in fact. That result is being approached rapidly. Our system is demonstrating by practice that it works.

"The theories which are advanced to entice the people into handling their private affairs over to the Government do not take into account all the fact. The fundamental characteristics of humanity are not going to be changed by substituting Government action for private enterprise. The individual who manages the one, with all his imperfections and his selfishness, will have to be employed to manage the other. The very essence of business is the expectation of a profit on the part of those who conduct it. Government is conducted from an entirely different motive. When business is in private hands, it is expected to be run for the benefit of the owners. When the Government steps in, the purchasers, users, and beneficiaries of what the Government undertakes to supply insist that the concern should be conducted for their benefit. It does not eliminate selfishness; it simply transfers it in part from the seller to the purchaser. Under these conditions it ceases to be a real business, becomes lacking in enterprise and initiative, and does not have any motive to provide improved service.

"Flowing out of these unavoidable conditions, if the Government gets into business on any large scale, we soon find that the beneficiaries attempt to play a large part in the control. While in theory it is to serve the public, in practice it will be very largely serving private interests. It comes to be regarded as a species of Government favor and those who are the most adroit get the larger part of it. Men in public life are besought to secure places of employment for some persons in their locality and favorable contracts for others. The situation rapidly develops into a position of intrenched selfishness, where a great body of public employees and large outside interests are in virtual control, with the general public paying a high cost for poor service. With all the care that it is possible to exercise, a situation of this kind becomes entangled in favoritism and is always in greater danger of causing corruption and scandal.

"If it is desirable to protect the people in their freedom and independence, if it is desirable to avoid the blighting effects of monopoly supported by the money of the taxpayer, if it is desirable to prevent the existence of a privileged class, if it is desirable to shield public officials from the influence of propaganda and the acute pressure of intrenched selfishness, if it is desirable to keep the Government unencumbered and clean, with an eye single to public service, we shall leave the conduct of our private business with the individual, where it belongs and not undertake to unload it on the Government. We shall constantly remember that society can not take any short cuts. It can not escape from itself. It can not get something for nothing. What it has, it must pay for. It can not shift, it can not dodge, it can not avoid meeting its own responsibilities. Any scheme to evade, however, specious it may appear, will prove to be only a delusion."

This same idea has recently been expounded in another vein in "An Address Delivered at the Sixth Annual Meeting of the Conference of American Executives held at the Washington Hotel, March 9, 1928" by W. D. Jamieson, of Jamieson & Ward, Attorneys at Law. It continues the protest against Government in business by citing the weakness of association activity in not taking a more vigorous stand and pushing forward their reforms in methods and management from within their own spheres.

"If you don't wake up and get on your jobs as associations, this same government will take a hand in your affairs, if your affairs are of sufficient importance to affect the great mass of the people, or of large communities of the people.

"And when the government does take such a hand in your business or your profession, you are apt to find it expensive, embarrassing, limiting, and maybe humiliating.

"In this day of increased efficiency and of higher ethics in all lines, one of two things is certain; either you will control yourselves voluntarily along lines of increased effectiveness for the general good of society, or sooner or later the government will assume more and more direction and supervision of your affairs.

"Your associations represent splendid scientific, professional, and business activities. As long as you fully measure up to your opportunities and your responsibilities, there is little likelihood the government will seriously interfere with you, provided you are actively and intelligently on the job to prevent such interference.

"Although you are voluntary in your organization, yet you are a very definite part of the government. In fact, your organizations are practically an associate government. In approximately the proportion that you legislate for yourselves will you prevent the Federal Government from legislating for you.

* * * * * *

"Probably there would have been no necessity at all for the Interstate Commerce Commission, with its burden of detail and expense and its lack of ability to respond easily and quickly to the needs of the railroads, I say there probably would have been no necessity for this Interstate Commerce Commission at all if the railroads themselves, through their various associations, had done the voluntary legislating for themselves instead of passing this duty over to the Federal Congress, which knows so little about the railroad business, and what is required of the roads for the public good.

* * * * * *

"There are two very marked distinctions between the hard and fast legislation of the government, and your own voluntary association legislation.

The first is that the government can legislate with definite authority, while you have been unable adequately to assert yourselves in the past. Your members may go to the Congress and make all kinds of pleas and all kinds of showings at the hearings, and lay down vigorous and well founded protests, but when the law is passed there is nothing for them to do except to obey it. If you could have this same sort of authority in your associations, I can see how you would practically obviate the necessity for added Federal legislation for your control.

"The second marked and serious difference, and which should give you pause, is that the hard and fast legislation of Congress is legislation by politicians who are thinking more largely in terms of the next election than anything else, while your voluntary legislation comes from men who are trained and efficient experts.

"Further, the administration agencies set up by the Federal government to regulate and control your various scientific, professional, and business activities are composed of men who know practically nothing about your business which they may be called upon to regulate. *In fact, in many of these Commissions a man who knows much about the business is prohibited from membership. A railroad man has no opportunity of being appointed Interstate Commerce Commissioner.*

* * * * * *

"I am inclined to believe there are entirely too many associations. * * * Can't you get your officers, or your directors, or your principals to see that things are entirely over-organized? That when they start a new organization on each possible excuse they are spreading themselves out entirely too thin to do effective work?

* * * * * *

"Mark this, if your association fails to have your line of business or your profession quit doing what it should not do, or if it fails to have it begin doing what it should do, then sooner or later this government will begin absorbing your legitimate activities. And when it once takes hold you can scarcely ever make it let loose."

High Government officers have proclaimed belief in these same principles. The following quotation is taken from Samuel Crowther's article in the *New York Herald-Tribune* of May 5th, 1928:

"The extraordinary fact of government finance is that we never know quite where the money comes from and never know entirely where it goes.

* * * * * *

"On the reorganization of the Federal government Herbert Hoover is informed and specific. He says:

"'The forty governmental agencies which are now supposed to function directly under the President present a problem. Here we have four breeds which might be classified according to the functions they perform: The semi-judicial, the semi-legislative, the service bureaus to all departments and the straight administrative. Often enough they are mixed. They are supposed to act under the direct supervision of the President, but it is preposterous to expect that with his multitude of higher obligations the President can give them anything like adequate supervision.

"'As a matter of fact, these independent establishments conduct their activities with very little supervision or co-ordination. The last group, the straight administrative, expends nearly $500,000,000 a year—as much as the total of five of the departments under Cabinet officers. If for no other reason this group should be placed directly in the departments in order that the President may exercise through his Cabinet the guidance and control of the administrative arm of the government. And the President, already overworked in the major policies, must be relieved of detail.

* * * * * *

"'No individual should be at the same time legislator, policeman, prosecutor, judge and jury. Yet in many instances he is. We arrive at judgments the best we can in old Kadi fashion, and the culprit usually knuckles down quietly, because he feels we might look for him again if he protested. The dangers of oppression in those matters are not merely a theory—they are a fact. All these confusions of functions were perhaps of less importance in days gone by, when our population was smaller and higher officials were less pressed with administrative work.

"'Every single department, bureau and board in the entire government should be placed upon the operating table and a clean-cut separation established between semi-judicial and semi-legislative functions on the one hand and of administration on the other. The former rightly belongs to boards of commissions, the latter to individuals. For instance functions arising from the navigation laws should be transferred to a properly constituted Shipping Board, leaving matters of administration of such decisions to the Department of Commerce.

* * * * * *

Reduction in Research Bureaus

"'Again, there are a great many bureaus at Washington which are given to important economic research. The boundary lines which separate these bureaus, one from another, are necessarily indeterminate. The business man who is accustomed to receive a bombardment of questionnaires from these establishments *has good reason to dread the extension of Federal encroachment upon business.* He would have much less cause for complaining if these government activities were grouped in such fashion that these matters fell under the control of fewer officials.

* * * * * *

[1]"'The National Conference on Street and Highway Traffic Safety, which was organized under the auspices of this department, has furnished a meeting ground for many different local and national groups. I sincerely hope that the present undertaking of this conference to draft a uniform municipal vehicle code will help the thousands of traffic officials and legislators who are earnestly seeking to solve their difficulties.

"'In this field of joint study of ways and means of handling administrative problems the drafting of uniform laws and ordinances has revealed many advantages. First, it insures systematic discussion of all relevant points, and the circulation of preliminary drafts always results in contributions from a far larger group of thoughtful men than could possibly meet profitably for extended oral discussion. Second, it brings out clearly the type of problems which can be handled best by voluntary co-operation with citizens and groups. Third, vast amounts of legal uncertainties and costly litigation can be avoided by careful study of existing provisions and the treatment they have received in the courts and detailed scrutiny of new proposals. Fourth, the contact of men who have had experience with various types of provisions under varying local conditions is of great help in sifting

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[1] Proceedings American Railway Engineering Association, Vol. 29, 1928, page 663, Report of A. H. Rudd, Ch. of Sub-Committee of Committee X, Signals and Interlocking. The Personnel of Sectional Committee on Code of Street Traffic Signs, Signal and Markings—D5 of the American Engineering Standards Committee was announced Sept. 5, 1928. A. H. Rudd represents the American Railway Association membership.

out sound and practicable measures from those which have unsound features. Fifth, uniformity is promoted where it is desirable, while on the other hand the way is left entirely free for the local experimentation and progressive development which are so fruitful and so firmly ingrained in our American tradition.

"'It would seem that the spirit of scientific co-operation will go far toward putting not only our Federal but also our local houses in order.'"

This is sound standardization doctrine; its practices are based on sound economical principles eminently worthy of further consideration of this Committee, and the American Railway Engineering Association.

In Memoriam

EDWIN B. KATTE

(Chief Engineer, Electric Traction, New York Central Railroad)

Died July 19, 1928

Committee work engenders friendships by reason of the common aim to be leaders in the announcement of an idea, which has been evolved by their solidary efforts, so original, new and high that it will be accepted gladly by their associates as the best "recommended practice" for the time being.

Katte was that kind of a man, and his associates of this Committee express their sorrow by his death.

Respectfully submitted,

Special Committee on Standardization,

W. C. Cushing, *Chairman.*

Appendix A

American Engineering and Industrial Standards

Officially Approved and For Sale at Cost

by the

American Engineering Standards Committee

29 West Thirty-ninth Street

New York

AMERICAN ENGINEERING AND INDUSTRIAL STANDARDS

Officially Approved and For Sale at Cost by the

AMERICAN ENGINEERING STANDARDS COMMITTEE

A—CIVIL ENGINEERING

		Price
A 1-1922	Portland Cement, Specifications and Tests for	Under Revision
A 2-1926	Fire Tests of Materials and Construction, Specifications for	.25
A 5-1921	Toughness of Rock, Test for	.25
A 6-1925	Drain Tile, Specifications for	.25
A 9-1927	Building Exits Code	1.00
A 11-1921	Lighting Factories, Mills and Other Work Places, Code of	.10*
A 14-1923	Ladders, Safety Code for	.05*
A 17-1925	Elevators and Escalators, Safety Code for	.60
A 19-1923	Concrete, Method of Test for Voids in Fine Aggregate for	.25
A 23-1924	Lighting of School Buildings, Code for	.10*
A 26-1924	Stone, Slag, Gravel, Sand and Stone Block, Sampling	.25
A 27-1924	Coarse Aggregates, Test for Apparent Specific Gravity of	.25
A 31-1924	Cement Grout Filler for Brick and Stone Pavements	.25
A 38-1927	Spiral Steel Rods for Concrete Reinforcement	.05*

B—MECHANICAL ENGINEERING

B 1a-1924	Screw Threads for Bolts, Machine Screws, Nuts and Commercially Tapped Holes	.50
B 2-1919	Pipe Thread	.40*
B 4a-1925	Tolerances and Allowances for Machined Fits in Interchangeable Manufacture	.50
B 5a-1927	T-Slots, their Bolts, Nuts, Tongues and Cutters	.35
B 6b-1927	Tooth Form of Spur Gears	.35
B 7-1926	Abrasive Wheels, Safety Code for the Use, Care and Protection of	.05*
B 8-1922	Foundries, Safety Code for the Protection of Industrial Workers in	.25*
B 11-1926	Power Presses and Foot and Hand Presses, Safety Code for	.20*
B 13-1924	Logging and Sawmill Machinery, Safety Code for	.60*
B 15-1927	Power Transmission Apparatus, Mechanical, Safety Code for	.10
B 16a-1928	Cast Iron Flanges and Flanged Fittings for Maximum Pressures of 125 lbs.	.50
B 16b-1928	Cast Iron Flanges and Flanged Fittings for Maximum Pressures of 250 lbs.	.50
B 16c-1927	Malleable Iron Screwed Fittings for Maximum Pressures of 150 lbs.	.40
B 16d-1927	Cast Iron Screwed Fittings for Maximum Pressures of 125 and 250 lbs.	.35
B 16e-1927	Steel Flanges and Flanged Fittings for Maximum Pressures of 250, 400, 600, 900, and 1350 lbs.	.50
B 17a-1924	Diameters and Lengths of Cold-Finished Shafting	.20
B 17b-1925	Keys, Square and Flat Stock, Widths and Heights	.20
B 17c-1927	Design of Transmission Shafting, Code for	.75
B 17d-1927	Keys, Plain Taper Stock, Square and Flat	.20
B 17e-1927	Keys, Gib Head, Taper Stock, Square and Flat	.20
B 18a-1927	Small Rivets	.30
B 18b-1927	Wrench Head Bolts and Nuts and Wrench Openings	.35
B 18e-1928	Round Unslotted Head Bolts	.40
B 18f-1928	Plow Bolts	.50
B 24-1927	Forging and Hot Metal Stamping, Safety Code for	.15*
B 26-1925	Screw Threads for Fire Hose Couplings	.25
B 28a-1927	Point of Operation Hazards of Rubber Mills and Calenders	.05*

* May be ordered from the Superintendent of Documents, Washington, D. C. (Money Order or Cash).

C—ELECTRICAL ENGINEERING

			Price
C	1-1926	Electric Wiring and Apparatus in Relation to Fire Hazard, Regulations for ("National Electrical Code"—Edition of 1926)	.05
C	2-1927	Electrical Safety Code ("National Electrical Safety Code")	1.00*
C	6-1925	Terminal Markings for Electrical Apparatus	Under Revision
C 8d	1-1928	30% Rubber Insulation for Wire and Cable for General Purposes	In Press
C 8j	1-1928	Cotton Covered Round Copper Magnet Wire	In Press
C 8j	2-1928	Silk Covered Round Copper Magnet Wire	In Press
C 8j	3-1928	Enameled Round Copper Magnet Wire	In Press
C	10-1924	Symbols for Electrical Equipment of Buildings	.10
C	11-1927	Aluminum Conductors, Hard Drawn, Standards for	.20
C	12-1928	Meters, Electricity, Rules for ("Code for Electricity Meters")	In Press
C	13-1926	Poles, Tubular Steel, Specifications for	.25
C	15-1923	Trolley Construction, 600 Volt Direct-Current Overhead, Recommended Specifications for	.30
C	18-1928	Dry Cells	In Press
C	19-1928	Control Apparatus, Industrial (Electrical)	In Press
C	21-1926	Converters, Synchronous	.40
C	22-1925	Transformers, Instrument	.30
C	25a-1928	Rating Provisions for Induction Motors and Induction Machines in General	.40

D—AUTOMOTIVE (Automobile and Aircraft)

D	1-1925	Aeronautics, Safety Code for	$1.50 each up to 5 copies 1.00 each 6 to 20 copies .75 each over 20 copies
D	2-1922	Automobile Headlighting, Safety Code for—Laboratory Tests for Approval of Electric Headlighting Devices for Motor Vehicles	Under Revision
D	3-1927	Colors for Traffic Signals, Safety Code for	In Press
D	4-1927	Automobile Brakes and Brake Testing, Safety Code for	.10

E—TRANSPORTATION

E	2-1923	Rails, Joint Plates for Seven-Inch Girder Grooved and Girder Guard, Recommended Design for	.20
E	3-1923	Rails, Joint Plates for Nine-Inch Girder Grooved and Girder Guard, Recommended Design for	.20
E	4-1923	Rail, Seven-Inch Girder Grooved, Design for	.20
E	5-1923	Rail, Nine-Inch Girder Grooved, Design for	.20
E	6-1923	Rail, Seven-Inch Girder Guard, Design for	.20
E	7-1923	Rail, Nine-Inch Girder Guard, Design for	.20
E	8-1926	Rail, Seven-Inch, 82-Pound Plain Girder for Use in Paved Streets, Recommended Design for	.20
E	9-1926	Rail, Seven-Inch, 92-Pound Plain Girder for Use in Paved Streets, Recommended Design for	.20
E	11-1926	Rail, Seven-Inch, 102-Pound Plain Girder for Use in Paved Streets, Recommended Design for	.20

G—FERROUS METALLURGY

G	9-1924	Forgings, Carbon-Steel and Alloy-Steel Blooms, Billets and Slabs for, Specifications for	.25
G	12-1923	Bars, Refined Wrought-Iron, Specifications for	.25
G	13-1923	Plates, Wrought-Iron, Specifications for	.25

* May be ordered from the Superintendent of Documents, Washington, D. C. (Money Order or Cash).

			Price
		H—NON-FERROUS METALLURGY	
H	4-1921	Copper Wire, Soft or Annealed, Specifications for	Under Revision
H	7-1925	Brass Forging Rod, Specifications for	.25
H	8-1925	Brass Rod, Free-Cutting for Use in Screw Machines, Specifications for	.25
H	10-1924	Ingot Metal, Brass, for Sand Castings, Specifications for	.25
H	11-1924	Solder Metal, Specifications for	.25
H	13-1925	Outside Dimensions of Plumbago Crucibles for Non-Tilting Furnaces in Non-Ferrous Foundry Practice	.20
		K—CHEMICAL INDUSTRY	
K	2-1927	Gas Safety Code	.20
K	3-1921	Manganese Bronze, Methods of Chemical Analysis of	.25
K	4-1921	Gun Metal, Methods of Chemical Analysis of	.25
K	5-1922	Alloys of Lead, Tin, Antimony and Copper, Chemical Analysis of	.25
K	8-1923	Liquids, Volatile, Flammable, Method of Test for Flash Point of	.25
K	12-1921	Copper, Methods for Battery Assay of	.25
		M—MINING	
M	2-1926	Electrical Equipment in Coal Mines, Safety Rules for Installing and Using	.05*
M	4-1922	Explosives, Permissible, Specifications for the Testing and Use of	.10
M	6-1927	Drainage of Coal Mines	.50
M	7a-1927	Mine Tracks and Signals	.50
M	11-1927	Wire Rope for Mines	.50
M	13-1925	Rock Dusting of Coal Mines, Recommended Practice for	.25
M	19-1928	Loading, Underground, Mechanical, in Metal Mines	In Press
		O—WOOD INDUSTRY	
O	1-1924	Woodworking Plants, Safety Code for	.05*
O	3-1926	Ties, Railroad, Specifications for	.25
O	4a-1927	Standard Methods of Testing Small Clear Specimens of Timber	.25
O	4b-1927	Standard Methods of Conducting Static Tests of Timbers in Structural Sizes	.25
		P—PULP AND PAPER INDUSTRY	
P	1-1925	Paper and Pulp Mills, Safety Code for	.15*
		Z—MISCELLANEOUS	
X	1-1921	Coal, Method for Sampling of	.25
X	2-1922	Heads and Eyes of Industrial Workers, Safety Code for the Protection of	.10*
Z	6a-1928	Dimensional Standards for Cutting, Splicing, and Perforating Motion Picture Film, and for the Apertures, Projection Lens Diameters and Sprockets of Motion Picture Projectors	In Press
Z	6b-1928	Recommended Practice in the Taking and Projection of Motion Pictures	In Press
Z	7-1925	Illuminating Engineering Nomenclature and Photometric Standards	.15
Z	8-1924	Laundry Machinery and Operations, Safety Code for	.05*
Z	10f-1928	Mathematical Symbols	.30
Z	12a-1927	Installation of Pulverized Fuel Systems	.10* (Z 12a–12e)
Z	12b-1927	Pulverized Systems for Sugar and Cocoa	
Z	12c-1927	Prevention of Dust Explosions in Starch Factories	
Z	12d-1928	Prevention of Dust Explosions in Flour and Feed Mills	
Z	12e-1928	Prevention of Dust Explosions in Terminal Grain Elevators	
Z	17-1927	Preferred Numbers (Informally approved and recommended for a period of trial in practice.)	.20

* May be ordered from the Superintendent of Documents, Washington, D. C. (Money Order or Cash).

Appendix B

EXTENT OF USE OF A.R.E.A. RECOMMENDED PRACTICES ON THE ILLINOIS CENTRAL RAILROAD

Committee I—Roadway

In a general way, we are following the recommended practice.
Definitions as given by Committee are applicable to our work.
General Contract Requirements are practically the same as we use.
We follow similar practice as recommended under:

Width of Roadway at Subgrade,
Specifications for the Formation of the Roadway,
Shrinkage and Subsidence,
Grade Reduction Work,
Track Elevation Work,
Waterways,
Slides,
Washouts,
Surface and Sub-Surface Drainage,
Tunnels,
Tunnel Ventilation,
Specifications for Sodding with Bermuda Grass,
Means for Prevention or Cure of Water Pockets in Roadbed,
Drainage of Roadway Through Stations and Yards,
Slides and Economics of Filling Big Openings.

Material appearing under:

Mechanical Shovels,
Locomotive Cranes and Dragline Excavators,
Shovel Methods and Operations,
Tunnel Construction,

does not apply to us so directly, due to the fact that our heavy grading work and tunnel construction is done by contract.

Committee II—Ballast

In making arrangements for ballast we follow practically the same methods as outlined and recommended by the A.R.E.A. In general, the definitions of the Committee apply to our work and we adhere closely to the practice as recommended under the following:

Specifications for Stone Ballast (we use size ⅝ inch to 2½ inch),
Specifications for Pit Run Gravel,
Cinder Ballast,
Specifications for Washed Gravel Ballast,
Specifications for Ballast Shovels,
Use of Mechanical Tampers,
Cleaning Ballast,
Ballasting by Contract.

Committee III—Ties

In making arrangements for the use of ties we do not follow A.R.E.A. specifications and recommendations as we have our own specifications.

In a general way, we do follow the A.R.E.A. recommendations for the following:

Specifications for Tie Plugs,
Installation and Keeping Records of Cross-Ties Test Sections,
Use of Dating Nails.

However, our tie plug is "straight" and does not show a "shoulder" as indicated by general design on page 11 of Volume 27, Bulletin No. 277, July, 1925.

Committee IV—Rail

Rail Sections: RA-A, 90 lb. RE, 110 lb.	Adopted as standard by the Illinois Central Railroad.

Specifications:

For carbon steel rails, 1925.	Used by the Illinois Central Railroad with principal modification of allowing test specimens under drop test to be head upwards instead of base upwards, as required by the A.R.E.A. Specifications. There are also other modifications of minor importance.
For girder rails.	Not used.
For spring washers.	The Illinois Central Railroad accepts manufacturer's specifications which are based on those of the Rail Committee.
For splice bars For track bolts	The Illinois Central Railroad uses the specifications of the A.S.T.M.

Design for Track Bolts:

Used by the Illinois Central Railroad with slight modifications.

Drilling of Rails:

Not used.

Standard Locations of Borings for Chemical Analysis and Tensile Test Pieces:

Used by Illinois Central Railroad.

Rail Record Forms:

1. Inspection and shipment.	The Illinois Central Railroad uses R. W. Hunt Company forms.
2. Rail Failures.	402-A. Greatly modified by Illinois Central Railroad Form No. 1137. 402-B. Not used. 402-C. Used with modifications. 402-D. Illinois Central Railroad Forms 1100 and 1125 are used. 402-E. Used by Illinois Central Railroad. 402-F. Used by Illinois Central Railroad.
3. Location Diagrams.	403-A. Not used. 403-B. Used with modifications. 403-C. Not used.

Committee V—Track

In a general way we are following the recommended practice.
Definitions as given by Committee are applicable to our work.
We follow similar practice as recommended under:

Maintenance of Line,
Maintenance of Surface,
Maintenance of Gage,
Width of Standard Flangeway,
Gage on Curves,
Temperature Expansion for Laying Rails,
Design of Track Fastenings,
Oiling Track Fixtures,
Resawing and reconditioning of Rails for Relaying, and Building up of Battered Rail Ends in Track,
Specifications for the Laying of New Track,
Specifications for Track Tools,
Specifications for Steel Cut Track Spikes,
Specifications for Steel Ties Plates,
Specifications for Wrought Iron Tie Plates,
Anti-Creepers. (Not practicable to confine ourselves strictly to these requirements, but in general way they cover the situation.)

In a general way we are following A.R.E.A. specifications for frogs and switches, but we have not attempted to use the A.R.E.A. lengths. We do not follow their specifications or recommendations for plain rail frogs, 90-lb. and under. We do follow the A.R.E.A. recommendations for Rail-bound Manganese Frogs and for all of our 110-lb. material; also for any new designs we expect to follow the A.R.E.A. recommendations as nearly as possible. We follow very closely the A.R.E.A. recommendations for all switches, except a change in dimensions, and we use the Notch Switch Heel Filler instead of the Pipe Thimble Heel Filler.

Committee VI—Buildings

Definitions of Terms:

We use, without exception, the definitions as recommended.

Freight Houses:

We follow in a general way recommended practices. We find, however, that no established practices can be followed very closely for buildings of this type as a great deal depends on local conditions and requirements. The present tendency in the design of buildings of this type is toward continuous doors along the track side of building and to eliminate the use of outside platform.

Oil Houses:

In general, we do not follow the recommended practice in providing separate building for oil houses. We find it is more economical from an operating standpoint to consolidate the oil with the store facilities. Oil room and basement, is, therefore, included as part of storehouse which permits the dispensing of oil by storehouse forces.

Passenger Stations:

In so far as it is possible, standard practices are considered. However, local conditions and requirements usually govern in each case of design, making it impractical to follow any definitely established recommendations.

Roofings:

We follow the recommended practice very closely.

Section Tool Houses:

We comply very closely with the recommended practice for this class of building.

Specifications:

We follow the recommended practice for specifications very closely except we include in our Scope of Work specifications some of the matter which the recommended practice places in the contract form.

Committee VII—Wooden Bridges and Trestles

We have not changed our plans or specifications for timber bridges to agree with A.R.E.A. requirements. In general, however, specifications for open deck and ballast deck bridges are very similar to those now proposed by the A.R.E.A.

Committee VIII—Masonry

For masonry we use A.R.E.A. specifications for reinforcing bars, and to a considerable extent we use the A.R.E.A. specifications for concrete.

Committee IX—Grade Crossing Design, Protection, and Elimination

Highway Crossing Sign:

We use a crossbuck sign where it complies with state requirements. Details vary from the A.R.E.A. plan.

General Specifications for Highway Grade Crossings and Approaches:

On new construction we build the highway embankment level for a distance of 30-feet out from the center of the track. This is similar to, but not exactly the same, as A.R.E.A. requirements.

Specifications for the Construction of Bituminous Crossings:

We have specifications for use of Kentucky Rock Asphalt which vary some from A.R.E.A. specifications. For other bituminous products we have used manufacturer's specifications.

Approach Warning Sign:

The approach warning sign used on our line is the same as shown in the Manual.

Committee X—Signals and Interlocking (Signal Section, Div. IV, A.R.A.)

The A.R.A. specifications cover all types of signal apparatus, including many things which are not applicable to our signaling. Of those that are applicable to our signaling the principal specifications not used are the following:

Rubber insulated wires and cables,
Lead storage batteries,
Conduit and conduit construction,
Gray and malleable iron castings,
Wrought iron bars,
Eastern white cedar poles,
Wood trunking and capping,
Weatherproof line wire,
Contract forms.

Committee XI—Records and Accounts

A. R. E. A. FORMS AND RECOMMENDATIONS			Reference			ILLINOIS CENTRAL SYSTEM FORMS	
Origin	Title of Form	Form No.	1921 Manual Page	Bulletin No.	Bulletin Page	Form No.	Description
(A) Design and Construction Department							
Foreman	Time Roll	1119	525			1142-A	Same, with modification.
Inspector	Pile Record Form	701	287				(Bl. line print) Same, with modification.
Matl. Inspector	Examination of Rails	401A Rev		295	926	2052	Identical.
	Certificate of Insptr	401B Rev		295	927	2018-C	Identical.
	Report of Shipment	401C Rev		295	929	2050	Identical.
Resident Engineer	Daily Trk. Laying Rpt	1100	501				(Bl. line print) Similar information but different form.
	Daily Ballasting Rpt	1101	502				
	Monthly Estimate of Grading	1102	503				
	Monthly Estimate of Bridges and Other Roadway Items	1103	504				
	Monthly Estimate of Buildings	1104	505				Not used.
	Progress Profile	1122	540				Same, with modification.
	Steam Shovel Reports						(Mimeograph) Same, with modification.
Electrical Engineer	Elec. Wiring Symbols			249	35		Identical.
	Form of Agreement for Pur. of Elec. Energy			289	49		Generally the same to suit particular cases.
Signal Engineer	Conventional Signs for Signals and Interlockers		554				Identical.
Asst. Engr.	Consolidated Monthly Estimate	1105	506				(Bl. line print) Same, with modification.
Ch. Engr.	Authority for Expenditure	1113	513				(See Valuation Department.)
	Detailed Estimate	1114 Rev		249	32		(See Valuation Department.)
	Form of Proposal	954					Same, with modification.
	Construction Contract			293	439		
	Form of Bond	967					
	Conventional Signs, Maps and Profiles	541					Same, with very little modification.
	Conventional Signs, Architectural Details			257	33		
	Specifications for Maps and Profiles	530					
	Form of Option for Purchase of Land			278	65	L&T 44	Similar, but varied for different states in accordance with requirements.
(B) Maintenance Department							
Foreman	Time Rolls	1119	525			1142A	Same, with modification.
Track Foreman	Report of Rail Failure, M.L.	402A	146			1137	Same, with modification.
	Monthly Report of Track Material	1107	508				Not used.
	Rept. of Work Order Work			250	77		Not used.
	Daily Record of Trk. Work			250	56G		Not used.
	Motor Car Operator and Mtce. Monthly Rept			289	48-2	1176	Similar information but different form.

A. R. E. A. FORMS AND RECOMMENDATIONS						ILLINOIS CENTRAL SYSTEM FORMS	
Origin	Title of Form	Form No.	Reference 1921 Manual Page	Bulletin No.	Page	Form No.	Description
(B) Maintenance Department—Continued							
Bridge Foreman	Monthly Bridge Mtl. Report	1108	509			1172	Same, with modification.
	Bridge Section Tool Report	1109	509				Not used.
Painter Foreman	Bldg. Painting Rept	600		287	66		Not used.
Steam Shovel Foreman	Steam Shovel Repts						(Mimeograph) Same, with modification.
Pumper	Pumper's Daily Rept	1301	677			1492(a)	Br. Inspector's Monthly Report.
Bridge Inspector	Current Bridge Inspection Report	1111	512			1173(a)	Br. Inspector's Monthly Report.
Motor Car Inspector	Motor Car Condition Report			289	47		Not used.
Gen. Br. Inspector	Bridge Inspection Report	1110	510			EB 6	Same, with modification.
Signal Maintainer	Signal Maintainer's Report	RSA-21				1197B	Same, with modification.
	Signal Inspector's Report	RSA-22				SD-23-24-25	Same, with modification.
Signal Supvr.	Trainmen's Telegraph Rept.	RSA-11				1197	Same, with modification.
	Dispatcher's Telegraph Report	RSA-12				1197E	Same, with modification.
	Signal Engr. Report	RSA-3				1197J	Same, with modification.
Div. Engr.	Monthly Rail Failures	402-B	149				(Bl. line print) Same, with modification.
	Statement of Rails in M. T.	402-D	151				Not used.
	Statement of Cost of Pumping Water	1302	678			1174	Same, with modification.
	Water Sta. Record	1303	679				(Bl. line print) Same, with modification.
	Record of Deep Wells	1304	680				(Bl. line print) Same, with modification.
Supvr. Wood Preserving Plant	Report of Inspection of Treatment	1700	851				Not used.
	Report of Inspection of Treatment	1701	852				Not used.
Supvr. Work, Eqpt. and Rdway. Machines	Recap. of Roadway Motor Car Rept			289	48	ED207	Same, with modification.
	Rdway. Motor Car Service and Mtce			289	48-4		Similar information but different form.

Origin	Title of Form	A. R. E. A. Form No.	Reference: 1921 Manual Page	Reference: Bulletin No.	Reference: Bulletin Page	Illinois Central System Form No.	Description
(B) Maintenance Department—Continued							
Engr.M/W	Authty. for Exp.	1113	513				(See Valuation Dept.)
	Detailed Estimate	1114 Rev		249	32		(See Valuation Dept.)
	Contract and Lease Record	1120	520				Same, with modification.
	Track Chart	1121	539				Same, with modification.
	Rail Failures for Yr.	402C Rev.		295	930	402-C	Identical.
	Stmt. of Transverse Fissure Rail Failures	402E Rev.		295	932	402E&F	Identical.
	Location Diagram of Rails Removed	403A	152			1138	Similar information but different form.
	Diagram Showing Lines of Wear	403B	153				(Bl. print) Same, with modification.
	Statement of Comparative Wear of Test Rail	403-C	154				Similar information but different form.
	Side Trk. Record	1106	510-11				(xSee footnote.)
	Register of Title Deeds	DV107-108					(*See footnote.)
	Forms of Agreement for Trackage Rights			267	58		Not used. (Each case handled in accordance with existing conditions.)
	Form of License for Wires, Pipes, etc., on Ry. Property			267	65		Similar information but different form.
	Form of Agreement for Placing Snow or Sand Fences beyond Railway Property			267	67		Not used. (Each case handled in accordance with existing conditions.)
	Form of Agreement for Jt. Use of Pass. Sta. Facl.			278	59		Not used. (Each case handled in accordance with existing conditions.)
	Form of Agreement for Jt. Use of Poles on Ry. R/W.			289	52		Not used. (Each case handled in accordance with existing conditions.)
	Form of Agreement for Furnishing Ry. Water to Employes and Others			293	467		Not used. (Each case handled in accordance with existing conditions.)
(C) Valuation Department							
Supvr. V.O. No. 3	Register of Authorities	1115	517			EA-9	Discontinued.
	Rdway. Completion Repts.	1117 to 1117C	519			ED-74	Same, with modification.
	Equipment Completion Reports	1118 Rev		249	34	ED-12	Same, with modification.
Supr. R&E Accting. Branch	Monthly Report of Expenditures	1116	518			EA-3	Ledger Card (#See footnote).
Auditor of Capital Expends.	Authority for Expenditure	1113	513			1573-1573-A&C	Same, with modification.
	Detailed Estimate	1114 Rev		249	32	1573-B&D	Same, with modification.

NOTES: x Several reports are compiled which include similar information.

(a) Monthly report showing daily performance.

This record answers the same purpose but is designed differently for use in machine posting with less detail.

*** As of June 30, 1915—not kept up to date.**

Committee XII—Rules and Organization

Rules recommended by A.R.E.A. agree in a general way with Rules adopted by us and in many cases the Rules are verbatim. During the year 1925 we revised our "Rules for the Maintenance of Way and Structures" and used the A.R.E.A. Manual as a guide.

Committee XIII—Water Service

The Illinois Central Water Department follows the recommended practices of the A.R.E.A. very closely.

The following specifications as published in the Manual are followed on the Illinois Central with such slight changes as are necessary to meet our conditions:

1. Wooden water tanks, 50,000 and 100,000 gallon capacity.
2. Round hoops for wooden water tanks.
3. Timber substructures for 50,000 and 100,000 gallon water tanks.
4. Steel water tanks, all capacities.

The following specifications have been adopted without change:

1. Specifications for hydrated lime.
2. Specifications for quicklime.
3. Specifications for soda ash.
4. Specifications for sulphate of alumina.
5. Specifications for cast iron pipe and special castings.

The following recommended practices are also followed by this department:

1. Standard method of water analysis.
2. Method of calculating economies of water treatment.

The Water Service Department organization on the Illinois Central follows very closely the recommended organization as shown in the Manual.

Our standard Water Department forms vary somewhat from those shown in the Manual, namely:

1. Pumpers' daily report.
2. Statement cost of pumping water.
3. Water station record.
4. Geological record of wells.

Committee XIV—Yards and Terminals

Track Scale Specifications:

We follow these specifications very closely, except that we specify heavier bridge work and deck beams and a slightly larger pit.

The recommendations of this Committee consist largely of principles that should be followed in connection with the design of terminal projects. These principles are given consideration in the solution of particular problems on the Illinois Central. The Committee in addition has made studies of certain yard units and has recommended certain practices as to the width of platforms, driveways, track spacing, etc. These recommendations are being followed on the Illinois Central.

Committee XV—Iron and Steel Structures

We use A.R.E.A. specifications for steel railway bridges for fixed spans less than 300 feet in length, with some minor modifications.

Committee XVI—Economics of Railway Location

The A.R.E.A. recommendations are employed as a guide in calculating relative values of the saving in distance, curvature, and rise and fall. Other recommendations are followed as near as practicable, in meeting the special problems that arise.

Committee XVII—Wood Preservation

The practice of the Illinois Central in connection with Wood Preservation is almost identical with recommendations as set forth by the A.R.E.A. There is a slight difference which has to do with the quantity of creosote oil used in treatment of various classes of material, and in most instances the quantity used by the Illinois Central is greater than that recommended by the Association.

We do not treat trunking and capping as our standard, for this material is heart Louisiana red cypress.

Committee XVIII—Electricity

Definitions of Terms.	Used for reference.
Overhead Clearance Lines for Permanent Way Structures on Electrified Railways.	Used for reference.
Clearance Lines for Equipment and Permanent Way Structures Adjacent to Third Rail Structures.	Used for reference.
Railway Specifications for Electric Light, Power Supply and Trolley Lines Crossing Steam and Electric Railways.	Superseded.
Specifications for Wood Poles.	No occasion for use as yet.
Specifications for Galvanizing or Sherardizing on Iron and Steel.	Superseded.
Stone Conduits.	Used as a basis in preparing Illinois Central Specifications
Railway Specifications for Electric Wires and Cables.	Used as a basis in preparing Illinois Central Specifications
Railway Specifications for Underground Conduit Construction for Power Cables.	Used as a basis in preparing Illinois Central Specifications
Tungsten Lamp Standards.	Now obsolete. The latest Standards recommended by A.R.E.A. being used.
Electrolysis.	Used for reference.
Specifications for Adhesive Tape for General Use for Electrical Purposes.	Superseded.

Specifications for Rubber Insulating Tape.	Used.
Rules for Recommended Practice Relative to Oil Sidings Due to Stray Currents.	Superseded.
Specifications for Electric Light, Power Supply and Trolley Lines Crossing Railways	Used where there is no conflict with State regulations.
Specifications for Galvanizing or Sherardizing on Iron and Steel.	Used.
Rules for Recommended Practice Relative to the Protection of Oil Sidings from Danger Due to Stray Currents.	Used.
Specifications for Maintenance of Overhead Electric Supply Lines.	Superseded.
Specifications for Maintenance of Overhead Electric Supply Lines (New).	Used.
Specifications for the Joint Use of Poles for Power, Communication and Signal Circuits.	No occasion for use as yet.
Specifications for Friction Tape.	Used.
Specifications for Porcelain Insulators for Railroad Supply Lines.	Used as a basis in preparing Illinois Central Specifications

Committee XX—Uniform General Contract Forms

Form of Proposal:

Form not followed. However, same features are embraced in our form.

Form of Construction Contract:

Form not followed. We go into considerably more detail.

Form of Bond:

We do not use a bond of this nature, but require cash deposit in lieu thereof.

Form of Industrial Track Agreement:

Form not followed.

Form of Agreement for Interlocking Plant:

Form not followed.

Form of Agreement of Crossing of Railways at Grade:

Form not followed. Agreement drafted in each instance to meet the varying conditions.

Form of Lease Agreement for Industrial Site:

Form not followed.

Form of License for Wires, Pipes, Conduits, and Drain on Railway Property:

Form somewhat similar with the addition of specification for depth.

Form of License for Private Road Crossings:

Form not used.

Form of Agreement for Trackage Rights:

Form somewhat similar, varying to meet conditions.

Form of Agreement for Placing Snow or Sand Fences Beyond Railway Company's Property Line:

Not used.

Form of Agreement for Joint Use of Passenger Station:

Form somewhat similar.

Form of Option for Purchase of Land:

Form not followed, our form varying in the different states.

Agreement for Purchase of Electrical Energy:

Form not followed.

Agreement for Joint Use of Poles on Railway Rights of Way:

Not used.

In general it can be said that the Illinois Central does not follow very closely the recommended forms. However, the forms are of considerable value as a guide to good practice.

Committee XXI—Economics of Railway Operation

The contributions made by this Committee have been utilized to some extent in studies which have been made on the economics of railway operation on the Illinois Central.

Committee XXII—Economics of Railway Labor

Some of the recommendations made by Committee are followed very closely, as in a general way we follow practice as recommended under:

Methods of Maintaining Motor Cars,
Methods of Programming Maintenance of Way Work, Looking to the Most Economical Application of Labor,
Method of Obtaining and Handling Railway Employees,
Training and Educating Engineers or Employees in the Engineering Department in Maintenance Work,
Standard Methods for Performing Maintenance of Way Work for the Purpose of Establishing Units of Measure of Work Performed.

While we follow the scheme of distribution of force based on equated mileage, we cannot apply this system without considerable deviation therefrom, as:

Weather conditions,
Track and Roadbed Conditions,
Necessity for Heavy Rail and Ballast Renewals,
Difference in Density of Traffic,
Difference in Efficiency of Labor,

cause us to assign force to meet special conditions.

Committee XXIII—Shops and Locomotive Terminals

Engine House Design:

We follow closely the recommendations for engine house design with but few exceptions—the exceptions being that no provision is made in our design for overhead cranes and we prefer the asphalt block for flooring instead of concrete or wood block as recommended. Tamped cinder floors are used, however, in most of our houses.

Ash Pits:

We follow very closely the recommended practice for ash pits with the exception of the amount of engine storage space between the pit and turntable. We find from an operating standpoint that it is more satisfactory to store engines prior to going on ash pits and locate ash pits as close to roundhouse as possible so that after the fires have been knocked, engines can be handled into the house in the shortest space of time.

Freight Car Repair Shops:

We follow closely the recommended practice in so far as our particular operating methods will permit.

Passenger Car Shops:

We follow closely the recommended practice in so far as our particular operating methods will permit.

Storehouse for Shops and Engine Houses:

We follow in a general way the recommended practice for this class of building. However, we consider it unnecessary to make special provision for removal of oil tanks from basement.

Locomotive Coaling Stations:

We follow closely the recommended practices for coaling stations in so far as local conditions and operating requirements permit.

Appendix C

FORMAL ANNOUNCEMENT OF THE REORGANIZATION OF THE AMERICAN ENGINEERING STANDARDS COMMITTEE FOR THE PURPOSE OF ENLARGING THE SCOPE AND STRENGTHENING THE WORK OF INDUSTRIAL STANDARDIZATION ON A NATIONAL BASIS

On October 11, 1928, the *vale* meeting of the American Engineering Standards Committee was held, and immediately afterwards the *salve* meeting of the American Standards Association.

This reorganization is intended to mark a very important strengthening of the movement for industrial standardization and may, therefore, be considered as the beginning of a new epoch in this activity. Significant action by large industrial companies has already been taken, the announcement of which is given in the following extract from the Minutes:

"2016. Adjournment *sine die* of the American Engineering Standards Committee. The Chairman announced that the new Constitution had been ratified by 26 of the 29 member-bodies, 23 being necessary to make it effective, and it appeared that the American Engineering Standards might now adjourn *sine die*, thus making way for the formal Constitution of the new American Standards Association. It was agreed that reorganization having been completed by formal ratification of the member-bodies, the unfinished business before the A.E.S.C. should be carried out by the organization reconstituted under the revised Constitution as the American Standards Association. It was accordingly, upon motion by Mr. Quimby, seconded by Mr. Skinner, unanimously

VOTED

> that the joint meeting of the Main and Executive Committees of the American Engineering Standards Committee adjourn *sine die*.

"2017. American Standards Association Constituted. The meeting was then called to order as a joint meeting of the Standards Council and the Executive Committee of the American Standards Association, in accordance with Article IX of the revised Constitution, by Mr. Serrill as President of the Association, Mr. Cloyd M. Chapman by the same provision becoming Vice-President of the Association, and the new By-Laws (MC 680) becoming effective in accordance with Section C23 of the Constitution.

"2018. Election of Chairman of Standards Council. Mr. Skinner pointed out that the new Constitution and By-Laws contemplated the desirability of the Standards Council being presided over by a Chairman other than the President of the Association. He believed it exceedingly desirable that in the present instance Mr. Serrill should serve as Chairman of the Standards Council, as well as President of the American Standards Association, and he therefore nominated Mr. Serrill as Chairman of the Standards Council for the remainder of his term as President of the Association.

"The nomination having been seconded, Mr. Serrill was unanimously elected Chairman of the Council for the remainder of his term as President of the Association.

"2021. Advisory Committee (Min. 1677). Reporting for this committee, the Chairman stated that after a preliminary conference, a meeting had been held on July 19, 1928. While only two members of the committee, Messrs. Farrell and Cortelyou, were present, Mr. Loree had outlined his ideas by letter, and Mr. E. M. Herr, who was Chairman of the original conference which had appointed the committee, and Mr. Frank W. Smith, who had had a very successful experience in the former Ways and Means Committee, as well as Mr. A. W. Whitney, sat with the committee."

After thorough discussion a plan was approved whereby twenty large companies should be invited to underwrite $100,000 a year for three years. It had been proposed that the four large companies represented on the Advisory Committee, together with their respective subsidiaries, should each subscribe $10,000 a year, and other companies $5,000 a year. A part of the money thus raised would be spent in financing a campaign to greatly extend the sustaining membership of the Association, so as to put its finances on an adequate, permanent basis. The Consolidated Gas Company had already approved its share of the underwriting, provided the other companies would also agree. Mr. Loree, speaking for the Delaware and Hudson Company, had written that the size and scope of his organization did not warrant the underwriting, but Mr. Farrell hoped, however, that their affiliated and subsidiary companies might make up the amount. An affirmative reply was looked for from the General Electric Company. Mr. Farrell had not yet responded for the U.S. Steel Corporation, but he had formerly said that he would recommend a subscription of that amount to their finance committee. Members of the committee had signified their willingness to sign personally the letters to the other companies whom they would ask to join in the underwriting. They had also agreed to the use of their names in a widespread appeal for sustaining-membership.

Appendix D

INDUSTRIAL STANDARDIZATION. RELATIONSHIP OF BUREAU OF STANDARDS WITH AMERICAN STANDARDS ASSOCIATION

When the announcement by the Bureau of Standards of the appointment of an Assistant Director, Commercial Standards (page 14), was made October 15, 1927, a feeling of uncertainty concerning possible conflicting actions in this work arose in the minds of the officers of the American Engineering Standards Committee, which resulted in conferences with the officers of the Bureau of Standards for the purpose of defining the lines of activity of each.

The result of these conferences was reported to the American Standards Association October 11, 1928, and is so important that the memoranda from the Minutes are added for your information:

"2020. Co-operation with the Bureau of Standards (Min. 2008). The Chairman reported that conferences for the purpose of arranging a working basis for co-operative action between the American Standards Association and the Bureau of Standards had been held during the Summer months. Earlier in the year the American Engineering Standards Committee had officially approved the so-called "Platform Agreement," which had been recommended to the Bureau and the A.E.S.C. by the "Planning Committee" (Min. 1962). This 'Platform,' which proposed a division of the field of industrial standardization, had never actually been put into operation, and had, as a matter of fact, never been approved by the Director of the Bureau. After long and careful analysis of the whole situation, Dr. Burgess and the speaker had come to the conclusion that a different method of co-operation would be much more effective and would enable both organizations to render more satisfactory services to industry."

The commercial standards formulated by the Bureau of Standards differed in essential points from American Standards, inasmuch as they were in most cases hurriedly arrived at to meet a special situation, were tentative in character, and did not provide for representation of all interests concerned. They might be regarded as formulated to fill a temporary need, and as offering valuable material for advancement to or for further development into American Standards. While the name "Commercial Standards" was a logical term from the Bureau's point of view to distinguish them from Government standards, he believed that some other term would be much better from the point of view of industry. He had considered other terms, such as "Provisional Standards," but thought on the whole that "Advisory Standards" was about the best available.

The fact that the Government had entered the field of standardization should be faced, and its co-operation sought, since competition in the promulgation of standards was most undesirable, and Government aid could be made most helpful if the necessary adjustments were arrived at. He had, therefore, suggested to Dr. Burgess, that each commercial standard brought out by the Bureau should become a candidate for approval by the American

Standards Association as American Standard. On September 11, Dr. Burgess had called a meeting in his office to discuss the development of such a co-operative arrangement, at which Messrs. Burgess, I. J. Fairchild, R. M. Hudson, Calvin W. Rice, W. J. Serrill and C. L. Warwick had been present. A tentative outline of such a co-operative plan had been sketched. Neither he nor Dr. Burgess thought it desirable for the present that official action should be taken on either side. They believed, however, that it was extremely desirable that the plan be developed by trial with a few typical cases. Each organization should keep the other fully informed as to the development of all of its new projects from the very initiation. Each should attend the conferences held, and in some cases conferences might be called jointly. In this work the chief problem for the A.S.A. would be a determination of which of the four regular methods of procedure should be followed in A.S.A. approval of standards submitted through the Commercial Standards Unit.

REPORT OF COMMITTEE XIII—WATER SERVICE AND SANITATION

C. R. Knowles, *Chairman;*
C. M. Bardwell,
S. C. Beach,
O. W. Carrick,
R. W. Chorley,
R. E. Coughlan,
W. L. Curtiss,
J. H. Davidson,
B. W. DeGeer,
L. E. Elliott,
C. H. Fox,
E. M. Grime,
L. O. Gunderson,
J. P. Hanley,
J. R. Hickox,
R. L. Holmes,
S. C. Johnson,
H. F. King,
F. H. Kornfeld,
C. H. Koyl,
P. M. LaBach,
R. C. Bardwell, *Vice-Chairman;*
E. G. Lane,
J. J. Laudig,
W. B. McCaleb,
S. B. Mitchell,
W. B. Nissly,
A. B. Pierce,
J. W. Porter,
O. T. Rees,
H. H. Richardson,
R. W. Savidge,
H. E. Silcox,
D. A. Steel,
R. A. Tanner,
W. O. Towson,
H. W. VanHovenberg,
J. B. Wesley,
A. E. Willahan,
Dennistoun Wood,
F. D. Yeaton,

Committee.

To the American Railway Engineering Association:

Your Committee on Water Service and Sanitation presents below its report to the Thirtieth Annual Convention on the following subjects:

(1) Revision of the Manual.
Progress is reported in Appendix A.

(2) Pitting and Corrosion of Boiler Tubes and Sheets.
Progress report on this subject is submitted in Appendix B.

(3) Value of Water Treatment and Comparison of Methods.
Progress report on this subject is submitted in Appendix C (1) and C (2).

(4) Protective Coatings for Interior of Steel Water Tanks and Underground Pipe Lines.
Final report appears in Appendix D.

(5) Incrustation in Pipe Lines.
Final report appears in Appendix E.

(6) Use of Gravity and Pressure Filters.
Final report appears in Appendix F.

(7) Fire Protection and Prevention at Water Stations.
Final report appears as Appendix G.

(8) Design and Maintenance of Track Pans for Locomotive Supply.
Progress report appears in Appendix H.

(9) Methods used in obtaining Wells in Fine Sand Formation.
Final report appears in Appendix I.

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(10) Water Columns and Their Advantages in Delivering Water for Locomotives.
Final report appears as Appendix J.
(11) Federal and State Regulations Pertaining to Drinking Water Supplies.
Committee reports progress in Appendix K.
(12) Methods and Practices of Handling Water for Drinking Purposes by the Railroads.
Committee reports progress in Appendix L.
(13) Coach Yard Sanitation.
Committee Reports progress in Appendix M.
(14) Railway Sanitation—A Monograph.
The Association's Opportunity for Promoting Railway Sanitation, Appendix N.
(15) Outline of Work for Ensuing Year.

Action Recommended

Your Committee recommends the following action on its report:

(1) That the subject-matter in the Manual be again referred to the Committee for further study and report.

(2) That the report on pitting and corrosion of boiler tubes and sheets be received as information and the subject reassigned to the Committee for further study and report.

(3) That the progress report on the value of water treatment and methods followed in treatment be received as information and the subject reassigned to the Committee for further study and report.

(4) That the report on protective coatings for interior of steel water tanks and underground pipe lines be received as information and accepted as a final report.

(5) That the report on incrustation in pipe lines be received as information and accepted as a final report.

(6) That the report on use of gravity and pressure filters be received as information and accepted as a final report.

(7) That the report on fire protection and prevention at water stations be received as information and accepted as a final report.

(8) That the report on the design and maintenance of track pans for locomotive water supply be received as information and the subject reassigned to the Committee for further study and report.

(9) That the report on methods for securing wells in fine sand formation be received as information and accepted as a final report.

(10) That the report on the advantages of water columns be received as information and accepted as a final report.

(11) That the subject of Federal and State regulations pertaining to drinking water supplies be reassigned to the Committee for study and report.

(12) That the progress report on methods of securing and handling drinking water be received as a progress report and reassigned to the Committee for further study.

(13) That the subject of coach yard sanitation be reassigned to the Committee for further study and report.

Suggested Subjects for Next Year's Study and Report

(1) Continue study of subject-matter in the Manual with a view to recommendations for changes.

(2) Continue the study and report on the causes and extent of pitting and corrosion of locomotive boiler tubes and sheets, giving consideration to quality of water, character of metals, methods of manufacture and types of boiler construction.

(3) Continue study on relative cost of impurities in locomotive boiler water supply and value of treatment with respect to:

(a) Advantages of saturated lime solution as compared to milk of lime solution and practical methods of obtaining same.

(b) Advantages and economical features of Barium Treatment for some waters and recommended practices for locomotive supplies, this Committee to consider all costs of water treatment and uses.

(4) Study and report on methods of laying cast iron pipe, and prepare complete specifications for inclusion in the Manual.

(5) Study and report on various forms used by railroad water service departments, and prepare forms for inclusion in the Manual.

(6) Study and report on storage of water at water stations, including tanks, standpipes, storage and sedimentation basins and reservoirs.

(7) Study and report on Zeolite treatment with particular reference to treatment of water for locomotives, showing limitations of this form of treatment and possibilities in combination with lime-soda treatment.

(8) Continue the study and make final report on the design and maintenance of track pans for locomotive supply.

(9) Study and report upon the chemical control and general supervision of water softening plants.

(10) Study and report on importance of protecting boilers and boiler materials from corrosion and deterioration in storage with definite recommendations as to their protection.

(11) Continue the study of progress being made by Federal and State authorities on regulations pertaining to drinking water supply.

(12) Study and report upon methods and practices of securing and handling water for drinking and culinary purposes by the railroads.

(13) Study and report upon drinking water and coach yard sanitation, establishing contact with public health, medical and other bodies engaged in similar studies.

(14) Outline of work for ensuing year.

Respectfully submitted,

Committee on Water Service and Sanitation,

C. R. Knowles, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

C. R. Knowles, Chairman, Sub-Committee; W. L. Curtiss, C. H. Fox, E. M. Grime, L. O. Gunderson, H. F. King, F. H. Kornfeld, J. J. Laudig, S. B. Mitchell, W. B. Nissly, J. W. Porter, W. O. Towson, J. B. Wesley.

The Committee has been engaged in a study of the subject-matter with a view of determining what revisions or additions should be made, and have also assisted in the arrangement of the material to be included in the new Manual and in the work of Committee XII—Rules and Organization.

Appendix B

(2) THE CAUSES AND EXTENT OF PITTING AND CORROSION OF LOCOMOTIVE BOILER TUBES AND SHEETS, GIVING CONSIDERATION TO QUALITY OF WATER, CHARACTER OF METALS, METHODS OF MANUFACTURE AND TYPES OF CONSTRUCTION

O. T. Rees, Chairman, Sub-Committee; C. M. Bardwell, O. W. Carrick, R. E. Coughlan, W. L. Curtiss, J. H. Davidson, B. W. DeGeer, L. E. Elliott, E. M. Grime, L. O. Gunderson, S. C. Johnson, C. H. Koyl, P. M. LaBach, J. J. Laudig, H. H. Richardson, R. W. Savidge, Dennistoun Wood.

The work of the Committee, as outlined under "Outline of work for the ensuing year," is of necessity only a progress report.

Realizing as the Committee has in the past that much work and investigation on the subject of Pitting and Corrosion is being conducted by various committees and members of the leading technical societies of this and foreign countries, we as a Committee have not attempted to formulate any of the work of these organizations as it may apply to railway operation, but have attempted to assemble and co-ordinate such information as appears to be general in its nature and to outline if possible such corrective measures as will, if followed out, bring about a material reduction in the pitting and corrosion now being experienced.

In the study of corrosion we must consider two things—the metal which is being corroded and wasted away, and water, the medium through' which the wasting is taking place. It is quite true that without moisture or water corrosion does not occur, but it is equally true that the same water does not corrode the various types of steel or metal to the same degree.

The first step then to be taken is to give consideration to the proper kind of steel or metal to be used. The best water obtainable may be very corrosive to certain kinds of steel.

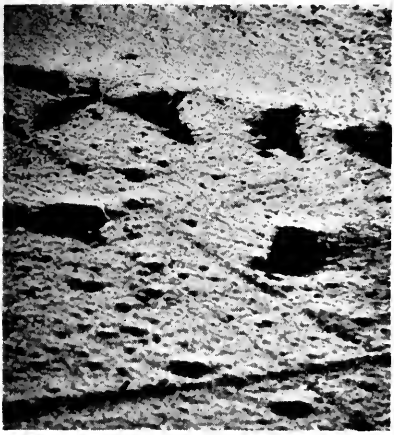

Fig. 1—Polished section of cold drawn flue which has pitted entirely through in eight months' service with mileage of 37,902.

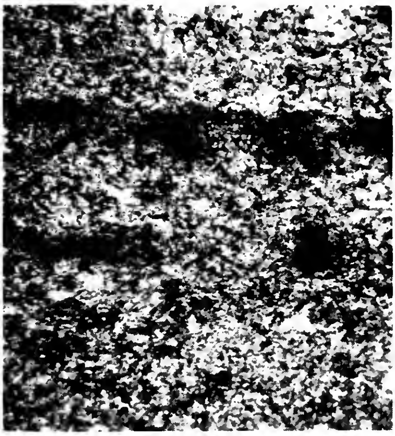

Fig. 2—Etched section of Fig. 1.

Fig. 3—Polished cross-section magnified four times of specimen from pitted superheater flue which had made only 89,038 miles. Metal below pit full of openings.

Fig. 4—Longitudinal Section of Fig. 3 showing manner in which porous metal extends from surface of flue downward more than half the thickness of the walls of the flue.

Flues and sheets are quite generally purchased according to specifications which cover the kind and amount of impurities or constituents and certain physical tests. It is true that the quality of the steel has been materially improved in recent years, and the fact that most of the specifications furnished in reply to our questionnaire have been revised or adopted within the past four or five years indicates that it has been recognized that the metal itself is at least partly responsible for the corrosion taking place.

The physical tests incorporated in most of the specifications are intended to correct faults in manufacture, chemical tests of faulty material having shown that certain elements may be present in proper amounts, yet for some reason the metal is not giving the service it should.

The accompanying microphotographs, Fig. 1 to 5, inclusive, serve to illustrate defects in flues which are evidently due to faults in their manufacture.

Fig. 5—Part of Porous Area Shown in Fig. 3 Magnified 100 Times

A close inspection of material used in the manufacture of flues and sheets, and of the processes used in their manufacture, has resulted in a greatly improved product.

The fact that a number of roads are making tests of flues of Toncan steel, an alloy steel carrying copper and molybdenum, and of leadized flues, neither of which is covered by specification, indicates that a better material than that secured by buying according to specification is being sought.

The roads making tests on flues of special steel containing certain alloys, and those with protective coverings, report more or less favorable results. These tests, however, have not yet been extensive enough or of sufficient duration to give positive information.

Pitting and corrosion are common to all roads heard from but there seems to be quite a difference in the amount and the location in the boiler where the attack is greatest.

It appears to be the common experience of all that the knuckle of the flue sheets and the areas around staybolts and radial stays are the points of greatest attack. These are points of greatest strain also. Although the rate of attack is dependent upon the character of the waters used to a large degree and can be reduced to a minimum by proper treatment or conditioning of these waters, yet it might be possible by some change in the design of the firebox to greatly relieve the strains and thus eliminate much of the trouble regardless of the water used.

A careful study of the types of water reported as being noticeably corrosive by the various roads replying to our questionnaire develops the fact that two types of waters are quite corrosive. One type is quite common to most roads; the other uncommon and may require special consideration to overcome its tendency to pit or corrode.

The type most commonly met with are those waters high in magnesium salts, especially the sulphate and more rarely the chloride. It has been quite generally understood that when magnesium chloride is present in a water, even in small amounts, it is corrosive, this condition being due to the decomposition of the magnesium chloride and resulting in the formation of free hydrochloric acid.

$$MgCl_2 + H_2O = 2HCl + MgO$$

When waters containing magnesium sulphate are evaporated the magnesium sulphate is decomposed in a similar manner, liberating free sulphuric acid.

$$MgSO_4 + H_2O = H_2SO_4 + MgO$$

Or, if both magnesium sulphate and sodium chloride (common salt) are present there is an interreaction forming magnesium chloride and sodium sulphate. In this case the magnesium chloride suffers decomposition liberating hydrochloric acid.

$$MgSO_4 + 2NaCl = MgCl_2 + Na_2SO_4$$
$$MgCl_2 + H_2O = 2HCl + MgO$$

Most of those reporting trouble from waters of this type are treating them with beneficial results, yet complete elimination of corrosion is difficult to secure because of the slow precipitation of the magnesium. As magnesium precipitates almost completely as hydrate it is quite evident that an excess treatment of caustic soda should be maintained for waters of this nature. A supplemental treatment with sodium aluminate will be found beneficial.

The second type of waters which has been found to be corrosive is low in solids and having a high hydrogen ion concentration. Corrosion due to the action of this kind can be eliminated or greatly reduced by lowering the hydrogen ion concentration by treatment with soda ash or by lime and soda ash proportioned to give an excess caustic soda of several grains per gallon, or by the use of a boiler compound of the proper type.

In the absence of sufficient sodium sulphate in the treated water resulting from the precipitation of the calcium and magnesium sulphates, and the sodium sulphate normally present to maintain the ratio 1 to 2 of total alkalinity as sodium carbonate to sodium sulphate, the A.S.M.E. code for boilers operating at a pressure between 150 lb. and 250 lb., it is advisable to bring the final treatment of the water to this condition by the use of acid, aluminum sulphate or iron sulphate, or some other of the embrittling inhibiting agents such as trisodium phosphate or tannates.

Because there appears to be a great difference in the way corrosion attacks the flues and sheets of engines operating under the same conditions

FIG. 6—SECTION OF CROWN SHEET SHOWING REPRESENTATIVE PITTING AND CRACKING DUE TO STRAINED CONDITION IN METAL CAUSED BY SOME RIGID BOLTS AMONG FLEXIBLE ONES

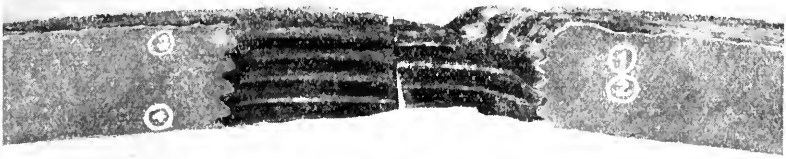

FIG. 7—CROSS-SECTION OF FIG. 6 OUTLINED BY WHITE MARK. BOLT REMOVED AND EXTENT OF CORROSION OF CRACKS SHOWN. CIRCLES INDICATE AREAS WHERE CORRESPONDING MICROPHOTOGRAPHS TAKEN

on the same districts using the same waters in very nearly equal amounts, it is felt that corrosion is in part at least an electrolytic phenomenon due to a variety of causes such as impurities in and segregation of the various constituents of the steel or iron, different kinds of steel or iron used in the same boiler, or of safe-ending flues with metal of a different type from the flue itself, strains in the metal, difference in concentration of solids and sludge in the boiler water, and of difference of temperature in the various parts of the boiler; also stray electrical currents from electrical equipment on trains and power plants adjacent to railroad facilities, but very little data is available on this phase except possibly that relating to strained metal. It seems to be the experience of most roads that the knuckles of flue sheets and the areas around stay bolts, both of which are continually subjected to strain, pit more than any other parts of the boiler.

The following photographs and microphotographs of a section of crown-sheet illustrate the location of strained metal about staybolts and show how it renders the metal subject to corrosion.

While it is considered quite certain that the included gases in water, especially oxygen, have a very vital effect upon the corrosion in locomotive boilers the data available to prove this is very limited. The rapid corrosion of the tubes in the preheaters of the mallets on roads operating this type of power and the comparative freedom from pitting of the tubes in the main part of the boiler seems to be a very strong argument in favor of this

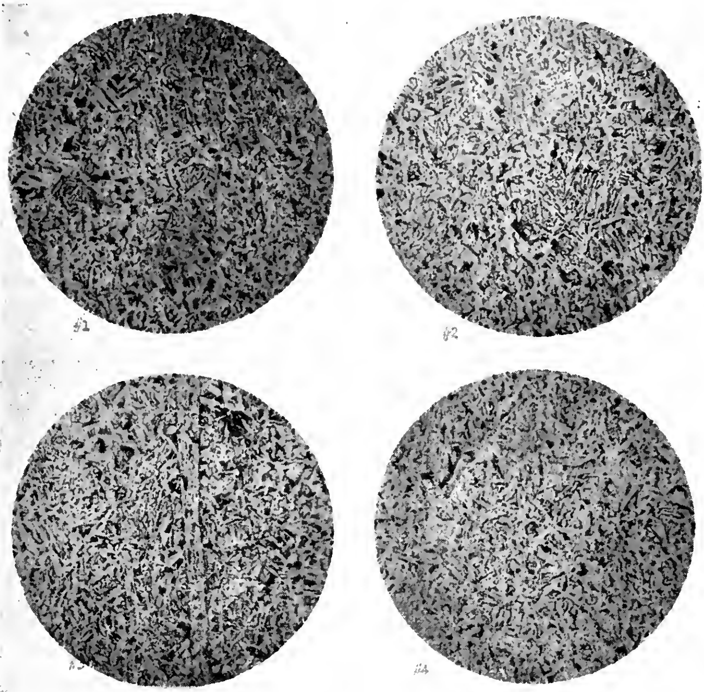

Fig. 8—(1)—Structure Near Water Side of Specimen Where Pitting Is Progressing. Strained Areas

(2)—Structure Near Middle of Specimen on Pitted Side of Hole. Center of Stressed Area

(3)—Structure Near Water Side of Specimen on Side of Hole Where There Was No Pitting. Structure More Nearly Parallel

(4)—Structure Near Fire Side of Specimen on Side Opposite to Pitted Area. Strained Areas Almost as Plainly Marked as Fig. 1

agency being a very important one. A type of feedwater heater has been constructed on the principle of eliminating a large per cent of these gases before the water enters the boiler. One of our Committee who has watched the operation of a locomotive of this type very closely reports very efficient results as far as the elimination of corrosion from this source is concerned. Speller points out that corrosion from this source may be practically eliminated if the hydroxide alkalinity is kept over 100 parts per million (5.8 grains per gallon) and the oxygen content of the feedwater is reduced to one cubic centimeter per liter or lower. The use of the hydroxide alkalinity, although not sufficient in most cases to prevent all pitting, is bound to have a beneficial action.

Many of the boiler compounds now being used are mixtures of material, inhibitive material with alkaline substances and organic emulsifying agents for oil, etc., so that no reliable data is available regarding the effects of any one material on corrosion.

While many roads are using the hot water boiler washing system and feel that beneficial results are being had, no reliable data is available at this time.

It has been noted by some of the roads who store engines that considerable corrosion takes place while the locomotives are out of service, but there seems to be some difference of opinion as to the best method for preventing it. Some advocate thoroughly drying and sealing up the boilers; others to blow out while hot and remove all plugs to allow free circulation of air. It is quite important that some means be devised whereby the damage from corrosion from this source be materially reduced.

Conclusions

1. Secure a metal highly resistant to corrosion.
2. Eliminate by specifications and inspection during process of manufacture defects in manufacture.
3. Careful consideration should be given to the design of locomotive boilers to eliminate as far as possible the undue strains.
4. Such equipment as feedwater heaters, so designed that the amount of included gases in the feedwater is reduced, should be utilizd.
5. The most corrosive type of water is one high in magnesium sulphate or chloride and should either be entirely eliminated as a supply or so treated as to remove the magnesium before the water enters the boiler, and sufficient excess causticity maintained to neutralize any dissociation of unremoved magnesium salt.
6. Waters corrosive account of having high hydrogen ion concentration should be so treated as to reduce the hydrogen ion concentration.
7. An excess of caustic alkali should be used to minimize the effect of included oxygen on corrosion.
8. Some method should be devised to give increased protection against corrosion inside of locomotive boilers while they are in storage.

Appendix C-1

(3) COST OF IMPURITIES IN LOCOMOTIVE WATER

(a) Report on Methods of Water Treatment Where Complete Lime and Soda-Ash Treating Plants Cannot Be Justified, or Pending Their Construction

C. H. Koyl, Chairman, Sub-Committee; R. C. Bardwell, O. W. Carrick, W. M. Barr, R. E. Coughlan, R. W. Chorley, J. H. Davidson, B. W. DeGeer, J. P. Hanley, P. M. LaBach, O. T. Rees, H. H. Richardson, J. B. Wesley, S. C. Johnson, H. W. Faus, L. E. Elliott.

In softening water for boilers it is desirable not alone that the calcium and magnesium be extracted, and the water therefore made soft, but that the carbonic acid and the sulphate radicle (combined with the calcium and magnesium) be removed and all precipitate separated from the water. At some early date we expect to have a satisfactory method and equipment for accomplishing all of this, and that will be the "complete" method, but meantime the lime-soda method accomplishes all but the removal of the sulphate radicle and therefore this method is called "complete" though it is not quite true.

The zeolite method makes water acceptably soft and leaves no precipitate but it fails to remove the carbonic acid and the sulphate radicle, both of which are left in the water combined with soda.

The soda-ash method precipitates the calcium and magnesium but fails to remove from the water either the precipitate, the carbonic acid or the sulphate radicle.

The best of the anti-scale compounds, whether fed to the water in the roadside tank or to the water in the boiler, merely precipitate in the water enough calcium or magnesium salt to insure a part, or sometimes all, of the remaining calcium and magnesium salts being brought down as sludge and not as hard scale on the flues or sheets; but these compounds contain (in addition to soda-ash) also organic matter which aids the precipitation and in some waters tends to prevent foaming.

None of these latter methods is as nearly "complete" for boiler purposes as is the lime-soda method, nor are they always cheaper in chemicals, but the construction costs are less and they are the methods in common use where, either because of low hardness or of small consumption, "lime-soda plants are not considered justified, or pending their construction."

Of these latter methods, circumstances may warrant the use of any one in particular cases.

The zeolite method is applicable where water is clean, free from iron and low in carbonate hardness. The softening of water by zeolite requires an equipment of tanks, pipe lines and valves, and storage for common salt, all of which must be housed for protection against rain and cold, but the equipment and housing cost less than a lime-soda plant, sometimes not more than half.

The soda-ash method is applicable to any water of low hardness, and is in use on four railroads for waters of hardness up to 70 grains-per-gallon; but in such practice the method of handling locomotives, particularly in the matter of blow-down, assumes an importance which overshadows the treatment itself and only a few roads have felt compelled to adopt it. On other roads, where soda-ash is used only on waters of low hardness, the present tendency is to substitute sodium aluminate for soda-ash in whole or in part because of the greater completeness of the chemical reaction and the consequent lesser tendency to foam in the boiler.

In all cases where soda-ash is used alone (or combined with sodium aluminate) as the softening and precipitating chemical, it is customary to dissolve it in water in the pumphouse and to pump the solution to the track tank, in proportion to the raw water, by a separate pump and separate pipe line from that used for the hard water—this to prevent deposition in the main pump and pipe line, to both of which the deposit would adhere.

The proprietary anti-scale compounds were formerly fed by the engine crew to the water in the engine tank, but because of irregularity in this work some of the compounds were made in brick form and of slow solubility, so that they could be placed in the boiler itself after washing and by the roundhouse men who were more interested than the engine crew in the preservation of the metal. Then, later, a greater uniformity of application was secured by feeding the compound to the water on its way to the roadside tank, by means of a by-pass around the pump for a small proportion of the water. The price of these compounds is necessarily high, and if much of the tank water is used for other than boiler purposes the last-named method of mixing may be wasteful.

We wish to say again that only clean soft water should go into a boiler, that all these methods for depositing sludge in a boiler are merely ameliorants and that the expression "complete treating plants are not justified" should be used with caution. One large western railroad had such maintenance and operating difficulties while its locomotives were handled by interior boiler treatment that it built 45 lime-soda plants on something over 1000 miles of road, and now supplies chemicals of all kinds for these plants at a less cost than was formerly paid for anti-scale compound, while the saving in operating expenses is not far annually from the construction cost of the plants.

The value to a railroad of water exactly suited to boiler use, that is, clean soft water free from carbonic acid and low in sodium sulphate and chloride, is so great that no imaginable price is prohibitive.

It is astonishing what damage is done to a boiler by water only a few grains-per-gallon hard, especially if there is a fraction of a grain of calcium or magnesium sulphate, and we reiterate our statement of 1927 (Proceedings, page 227) that "few natural waters are so good that some form of treatment does not improve them."

A valuable and timely paper on this subject, "The Treatment of Boiler Feedwaters of Low Incrustant Content," was presented at the April, 1928, Meeting of the American Chemical Society at St. Louis by S. C. Johnson,

Fig. 1, 2 and 3 Illustrate the Corrosion of Staybolts and Flues Resulting from the Use of the Waters Mentioned Above, Before They Were Treated with Soda-Ash

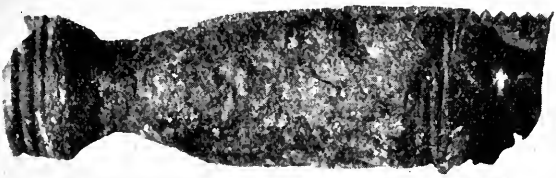

Fig. 1

Fig. 2

Fig. 3

Chief Chemist of the Water Supply Department of the Chesapeake and Ohio Railway. Mr. Johnson cites case after case to show that waters of low hardness do a great deal of harm to boilers unless they are treated with enough soda-ash, or its equivalent, to rid the water of all sulphate hardness and to make it sufficiently alkaline to precipitate the carbonate hardness as sludge.

The waters cited in the paper do not exceed 5 grains-per-gallon hardness, 4 grains alkalinity and 10 grains total dissolved solids. When used in their natural state the small amount of sulphate of lime in these waters, on precipitation by the heat of the boiler, binds the carbonate scale to the flues and sheets. One of these waters with carbonate hardness of 4.1 grains and sulphate hardness of .4 grain deposited a tenacious scale which in the case of one yard engine reached a thickness of ¾ inch on the cooler boiler surfaces.

Another water with carbonate hardness of 1.0 grain, sulphate hardness of 1.5 grains and total dissolved solids of only 6.0 grains, not only deposited a hard sulphate scale on the hottest part of the boiler but pitted the boiler from end to end and particularly under the sulphate scale.

A third water with carbonate hardness of 1.8 grains, sulphate hardness of 0.2 grain and total dissolved solids of 3.5 grains, deposited scale on all boilers and was sufficiently corrosive to cause an annual loss of $50,000 to a large local industry.

All these waters, and many others like them, were cured of their scale-making and corrosive qualities by the addition of a little soda-ash, usually less than one-half pound per thousand gallons of water. But the author takes pains to say "Blowdown control is very essential with soda-ash as with any other form of internal treatment, but it is often one of the most difficult tasks to have properly executed in the entire treatment cycle. For this reason it may almost be considered as a determining factor in the results obtained."

There is no question of the efficiency of soda-ash with waters of low hardness if the boilers are kept well blown-down, but there is much question as to the amount of hardness which can be thus taken out within the boiler without causing foaming in ordinary road work. On the Wabash, where soda-ash alone is used for water softening in the boilers, the waters of the railroad average about 15 grains-per-gallon of incrusting solids and it is said that blowing out of boilers prevents any undue foaming. Also both the Chicago & Alton and the St. Louis-San Francisco, with much harder waters, report satisfactory operation with the same methods.

Other roads have not all been able to deposit such quantities of sludge in locomotive boilers without foaming, which may be due to ineffective blow-down equipment, or to the inexperience of the men, or to the character of the water. The blow-down valves should be connected to perforated pipes extending certainly through the mud-ring and preferably also along the belly of the boiler. An engine crew is so busy that it dislikes extra boiler blowing. We now know that the sludge which causes foaming consists of the lighter particles which are easily carried to the top of the water, and waters vary materially in the character of the sludge which they deposit.

Where Is the Dividing Line?

It is much easier to enumerate and discuss the various kinds of treatment suited to waters slightly hard or slightly muddy or requiring adjustment of some other slight defect than it is to decide on the point below which the defect shall be called slight and above which the water shall be said to require treatment by a standard method, and the same applies to the question "How many gallons daily consumption at a hard-water station shall call for a softening plant?"

Before the value was recognized of water exactly suited to boiler use, this dividing line was set high and it was no uncommon occurrence to read a report that the water at such and such a station was 20 grains-per-gallon hard and that its softening by the lime-soda process would cost 4 cents per thousand gallons but that, because there were used 300,000 gallons per day, the daily cost would be $12 which was excessive and the project could not be considered.

Nowadays, thanks to the dissemination of knowledge by a rapidly increasing corps of Engineers of Water Service, the question is seldom asked "How hard must a water be to require softening?" but "Are there any waters on this railroad which do not require softening?"

The increase in knowledge comes from a more general realization of the fact that the business of a railroad is to operate trains regularly and on time, and that the cost of train delays from lack of dependability in the boiler far exceeds the cost of water softening and cleaning.

For many years the only savings estimated in dollars and cents were those from coal, boiler repairs and washing. The famous Committee of the American Railway Master Mechanics' Association of 1870 reported that for the locomotives of that day and as an average for the country, excluding most of New England and parts of the middle south where the water is good, the damage done by hard and muddy waters amounted to $750 per locomotive per year in additional coal, boiler repairs and washing. This sum when translated into similar terms for the locomotives and prices of today amounts to about $4000 per locomotive per year, and these figures are substantiated by our investigation and report to this Association in 1925. But this enormous loss is due to additional fuel and boiler maintenance only, and there is nothing included for the loss of engine time while undergoing these extra repairs and washings, nothing for the injury to train service from boiler failures on the road, nothing for train delays while waiting for engines from the roundhouse, nothing for the loss of spirit in the men from lack of dependability in the boiler.

On the parts of a railroad where damage in additional fuel and boiler repairs amounts to $4000 per locomotive per year, it is stated that the average time out of service undergoing backshop repairs is two months per year, or one-sixth of the engine's time, and if we adopt the usual figures of $20-$40 per day as the value to the railroad of an engine's time we have $1200-$2400 per year per locomotive as the commencement of our additional savings from the use of good boiler water.

In the other matters enumerated we can approximate definite figures by comparing the monthly reports of cost of operating a Division "before and after" the installation of water-treating plants, and in any such case it should be understood that the resulting economies depend largely on the ability of the Division Superintendent to utilize the improved condition. In one case on record it is stated that on a light traffic Division of 600 miles, after treating plants had been installed on 130 miles of very bad water near the middle of the Division, the Division operating cost dropped $25,000 per month solely because of the dependability of the locomotives. For one year this amounts to $300,000, or $500 per mile per year, or $6000 per year for each of the 50 locomotives employed.

A large part of this saving doubtless was due to the prevention of congestion at the two ends of the 130-mile engine district which was treated, and it might not be fair to distribute the saving only over the 130 miles or the 14 locomotives on it.

The value of water-treating will be apparent to anyone who considers the economies introduced by the long locomotive runs of today and knows that few of them would have been possible with the untreated locomotive waters of even fifteen years ago.

This proof of the importance of using in locomotives only the best of boiler water does not enable us to determine the point at which complete treatments with lime and soda, and either alum, ferrous sulphate or sodium aluminate, should end and only interior boiler treatment commence; but it shows the desirable qualities of boiler water and that for any particular water under consideration it is economical to install a plant for complete treatment unless interior treatment can effect these results without serious detriment to even one train per day. For most clean waters the dividing lines are at about 10 grains-per-gallon carbonate hardness, and 5000 gallons per day consumption.

Appendix C-2

(3) COST OF IMPURITIES IN LOCOMOTIVE WATER

(b) REVIEW PROGRESS IN WATER TREATMENT ON RAILROADS AND REPORT ON POSSIBLE FUTURE DEVELOPMENT

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The modern art of water softening began in Scotland in 1840, born of the genius of Dr. Thomas Clark, Professor of Chemistry at Mareschal College, Aberdeen.

Nowadays the chemistry of water softening is very simple but its beginning in the hands of Dr. Clark made one of the romances of science.

It is generally known that carbonate of lime, which in many localities is alone responsible for the hardness of water, is soluble in water only when the water contains carbonic acid, but Dr. Clark appears to have been the first to realize this and was certainly the first to apply a scientific remedy. His line of reasoning was that the extraction of the carbonic acid would make the carbonate of lime again insoluble and therefore precipitate it and leave the water soft. And what was more simple than to extract the carbonic acid by adding fresh lime, for which the carbonic acid has a strong affinity and with which it would unite to form more insoluble carbonate of lime (limestone), so that both the old limestone and the new would fall out of the water and leave nothing in it.

There is no remedy for any ill in nature more beautiful or complete than this. By adding hard lime water to hard natural water you take out limestone and leave soft water; and to this day, to the ordinary man who considers lime merely baked limestone, this is the most marvelous thing in the world. But it was the beginning of the science of water softening.

For some forty years this process, with the later addition of soda-ash to remove the sulphate of lime, was used in Great Britain and on the Continent for the softening of water for all purposes, including boilers, and was operated in two tanks alternately, one being used while the other was being filled and treated. Then for twenty years, which brings us to 1900, there was gradually introduced what we call the "continuous" process in which hard water continuously flows into one end of the plant, is continuously mixed with the proper amounts of lime and soda-ash, thence flows through a settling tank and is thence continuously pumped to the storage tank. By 1890, in England and in Europe, the advantages of soft water had become so well known that it was considered economically wise to go to the expense of softening hard water for almost all industrial purposes, and many different forms of "continuous" plants were designed.

In America, the first concentrated attention paid to the subject, according to our records, was in 1870. In that year the American Railway Master Mechanics' Association appointed a committee to report on the possibility of getting pure water for locomotives, the word "pure" meaning to them "suitable for boilers." This committee continued in service three years and during that time collected evidence to show that for the parts of the country having hard or muddy water the damage to locomotive boilers averaged $750 per locomotive per year, this being made up of extra boiler repairs $360, additional coal (at $2.50 per ton) $340, and additional boiler washing $50. Then the committee obtained the assistance of Professor Joseph A. Sewall of Illinois State University who showed them in the laboratory how water can be made suitable for boiler use by precipitation of its calcium and magnesium salts by fresh lime and soda-ash, but also informed them that nowhere in the country had there been worked up methods for doing this on a large scale. The committee's recommendations could scarcely have been improved but the state of the art of water softening in the country was so undeveloped at the time that nothing practical was done for more than twenty years.

The first plant for water softening in America appears to have been built in Ohio in 1896 and was practically a duplicate of Dr. Clark's plant of 1840. These dates seem old to us in this age of rapid invention but there is no better plant built today than was seen in Ohio in 1896, and many of the present day plants are not so good because they lack the thorough mixing of chemicals with water and old sludge and the consequently almost perfect settling of these old "intermittent" plants.

The first lime-soda water softening plant on an American railroad of which we have record was installed on the Rio Grande Western Railway at Helper, Utah, in the year 1900. It was a "continuous" plant, and in those days the lime was fed to the mixing tank in the form of saturated limewater so that this plant consisted of a lime-saturator, a small steel tub for dissolved soda-ash, a tank for mixing chemicals and raw water, and a settling tank with an excelsior filter, one foot thick, having its upper surface about 18 inches below the top of the settling tank. The top of the settling tank was level with the top of the roadside tank and connected to it by a 6-inch pipe, and it was all so arranged that when the roadside tank was full and the water in the settling tank was at its very top, all valves automatically closed and all operations stopped. The operation of this plant was so nearly perfect that the water which had risen through the excelsior filter was so clean that it was invisible except when the rays of the sun or some other light were reflected from its surface, and it is related that an engineer from a nearby railroad, when inspecting the plant and walking around the top of the settling tank on the platform provided for the purpose, decided to investigate the excelsior filter more closely and stepped down upon it only to discover that it was covered by 16 inches of water.

Since the year 1900 the installation of water softening plants on railroads has progressed steadily, most of the plants being of necessity on the northwestern roads where there is less good boiler water than on the eastern

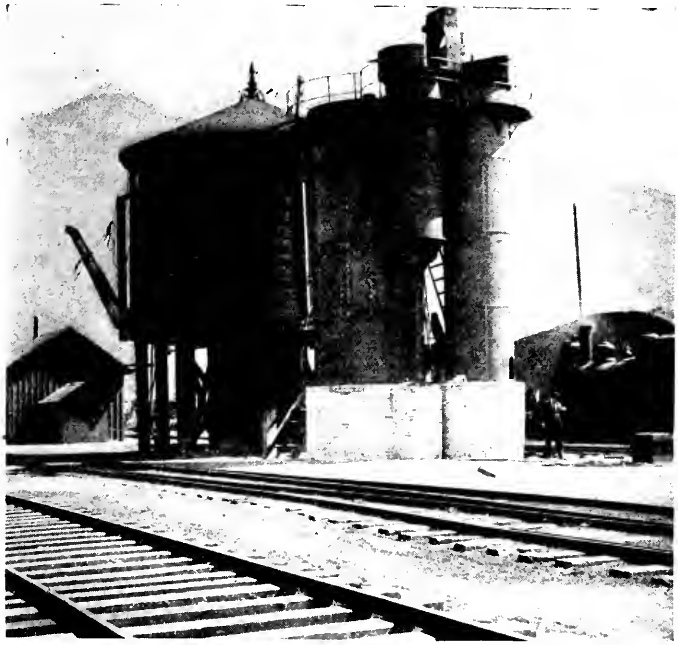


Fig. 1—Lime-Soda Water Softening Plant, Built by Dr. C. H. Koyl on Rio Grande Western Railway, Helper, Utah, 1900, Before Housing

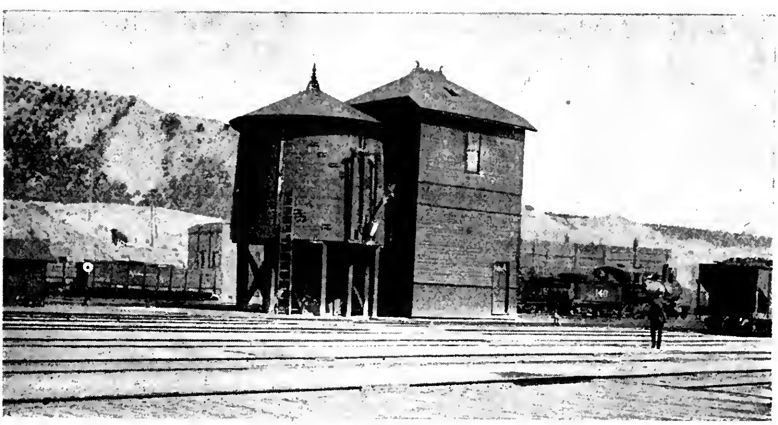


Fig. 2—Same as Fig. 1 After Being Housed

and southern roads. In 1910 there were about 100 lime-soda plants in operation for locomotive use, and the amount of water softened daily about 10 million gallons. In 1920 the number of plants in operation was at least 400 and the amount of water softened daily about 40 million gallons. In 1928 the number of plants is nearly 900 and the daily amount of water softened about 120-million gallons. In addition, there are some 650 plants using soda-ash, or sodium aluminate, only, and treating 45 million gallons daily; 330 plants mixing anti-scale compound with 39 million gallons daily of the water in wayside tanks; 35 zeolite plants softening 8 million gallons daily; and probably 40 million gallons daily using anti-scale compound in boilers. The total number of water stations on railroads in the United States is not far from 9000 and the daily amount of water 900 million gallons. At a later date we will furnish more complete and exact statistics.

When water softening plants are being designed for stationary boilers or for other uses about a large factory, they can be made practically automatic in operation so that the work of the attendant is limited to the daily filling of the chemical tubs and the daily discharge of sludge. The accurracy of treatment by such plants depends on the accurate operation of the automatic appliances and can be depended on in a factory where there are skilled mechanics to keep the appliances in order. But the case is different for the wayside tanks of a railroad and particularly in the northwestern country where the population is sparse and many of the plant attendants are unskilled with tools. In such cases the fewer automatic appliances the better, and there is always need for regular inspection, not only of the condition of the water but of the condition of the pumps and mechanical appliances of all kinds. The most important operating lesson we have all learned is that the condition of the treated water depends not alone on the amounts of chemicals but on the regularity of operation of pumps and other machinery, and that therefore the only place in which to inspect treated water is at the plant.

As to the future, we have high hopes. A few years ago scale and leaking were rampant in what we call the "bad water country" and were not unknown in other parts. Today such things are found only because the building of water softening plants has not yet covered the country.

Of foaming and priming in boilers we have something yet to learn but our knowledge is being rapidly increased by intensive study.

In the matter of pitting and general corrosion under water we have made definite progress. There are now in use on three railroads of the United States three different methods of preventing, or at least greatly reducing, boiler corrosion. These three-year demonstrations have been made on only a few locomotives, but they are successful and we expect to see the day, not far ahead, when locomotive boiler pitting will be a thing of the past.

Appendix D

(4) STUDY OF PROTECTIVE COATINGS FOR INTERIOR OF STEEL TANKS AND UNDERGROUND PIPE LINES

J. H. Davidson, Chairman, Sub-Committee; R. E. Coughlan, L. E. Elliott, C. H. Fox, E. M. Grime, R. L. Holmes, H. F. King, W. B. Nissly, O. T. Rees, R. A. Tanner, W. O. Towson, J. B. Wesley, A. E. Willahan, Dennistoun Wood, F. D. Yeaton.

The number of steel tanks in railway water service is rapidly increasing and the proper protection of their interior surfaces against pitting and corrosion has become a problem of considerable importance

For the purposes of this report the tanks are divided into three groups according to their use, as follows:

(1) Water storage tanks from which water is drawn for locomotives and general use. They may contain either treated or untreated water.

(2) Settling tanks for water softening plants. Many tanks are now used as combined settling and storage tanks.

(3) Tanks used in connection with hot water boiler washing plants.

Since the quality of the water and its temperature are important factors in the corrosion of steel tanks and the effectiveness of protective coatings in retarding this corrosion, the three classes of tanks named above will be considered separately.

Storage Tanks

Where the quality of the water is favorable, steel storage tanks have been in service 25 to 30 years without requiring extensive maintenance in the way of protective coatings and without any serious damage from corrosion. However, numerous cases are on record where tanks inadequately protected have required extensive repairs or have even failed in 15 years or less.

In general, storage tanks suffer more from corrosion on the areas exposed alternately to the action of water and air on account of the varying water level. This is usually general corrosion or rusting over the entire surface rather than pitting or grooving.

The materials most commonly used for protective coatings on the interior of these tanks are:

(1) Paints using linseed oil as a vehicle and various materials for pigment and filler.

(2) Asphaltic and coal tar paint in liquid form.

(3) Asphaltic and coal tar mastics which have to be applied hot.

(4) Materials with a petroleum jelly base and usually containing some rust inhibiting chemicals such as chromium salts.

(5) Emulsified asphalts.

(6) Portland cement grout.

Since paints containing linseed oil dry by oxidation, it is essential that such paints be allowed all the time possible for drying before being immersed. This is the chief objection to such paints, as it is usually impossible to keep a tank out of service long enough to insure the oxidation of the linseed oil sufficiently to insure a lasting protective coating. Special formulae of quick drying paints are desirable if other qualities are good. The following special formula is recommended:

100 lb. red lead in oil
1½ gal. boiled linseed oil
3 pints turpentine
2 pints liquid dryer.

When paint is ready to apply, add two pounds of finely powdered litharge to every gallon of paint. At least one week should be allowed between the priming coat and the second coat and at least 48 hours between the second and third coat and between the third coat and the time water is admitted to the tank.

Laboratory and service tests indicate that approximately three years is as long as a good coating of linseed oil paint can be expected to protect against pitting and corrosion.

(2) Asphaltic and coal tar paints in liquid form have the advantage of being rather quick drying and not requiring the tank to be kept out of service as long as with the linseed oil paints. There are a great many such paints on the market and two or three that have recently been introduced have given good results, although they have not been in service long enough to permit definite conclusions being drawn.

(3) Asphaltic and coal tar mastics applied hot in coatings of from ⅛ inch to ¼ inch in thickness over a priming coat of asphaltic paint have given very good service, as reports indicate some of these coatings in good condition after ten years' service. The cost of coating a tank with this material will be approximately three or four times greater than the cost of painting the same tank with red lead and linseed oil. However, the better protection afforded by the mastic and its longer life might make it more economical to use in many cases. Contractors will apply these materials and guarantee protection against corrosion for periods of from five to seven years.

(4) Compounds with a petroleum jelly base resembling vaseline to which some such rust inhibiting chemical as chromium salts has been added, have been highly recommended for protection of interior of water tanks against corrosion. The use of these materials as coatings for interior of steel water tanks has not extended over a sufficient period of time to permit definite conclusions as to its value to be made. Enough favorable reports have been received, however, to warrant extensive trial applications being made.

(5) Emulsified asphalts have not in most cases proven satisfactory as protective coatings for interiors of steel water tanks.

(6) Two middle western railroads have made extensive use of Portland cement grout as a protective coating for the interior of steel water tanks with gratifying results.

Instructions for applying this material as issued by one of these roads are as follows:

> Cement grout mixture
> 1½ parts by volume of Portland cement
> 1 part by volume of very fine sand
> Water sufficient to make a thick cream.

The tank should be drained and the lower course thoroughly cleaned before the cement grout is applied. This should be allowed to stand for an hour or two, then the second coat applied. After it has had another hour or so to set, the water can be run in to within a foot or so of the top of the coating and a raft supported by four barrels or floats can be made, for use as a scaffold in cleaning and painting the next course. The corners of the raft should be padded with burlap so that they will not mar the coating in case the raft jars against the sides of tank.

The second course can then be cleaned and the grout applied in the same manner as the first course, and each course taken care of until the whole tank is coated.

Important points are that only sufficient of the cement grout should be made up to apply before it takes initial set; and the mixture should be thoroughly brushed or stippled into the bottom of the pits.

The grout may be applied either with a paint or white wash brush and as much of it as will stick on is allowed to remain.

Fig. 1 and 2 show the interior of a 16-foot diameter by 65-foot high water treating tank which was erected in 1910 and thoroughly cleaned in 1918 and coated with cement grout as per above specifications. The photographs were taken October 10, 1923.

The cost of applying the cement grout is a little less than the cost of applying ordinary paint. The material used costs much less but the labor required is slightly greater.

The caustic alkalinity of water treated with lime and soda ash inhibits, to a certain extent, the pitting and corrosion of steel water treating tanks. In some localities it has been found unnecessary to apply protective coatings to the interior of these tanks, but in other places severe pitting has been experienced.

The coatings above described as used in storage tanks have also been used in water treating tanks. The caustic alkalinity of the treated water makes linseed oil paints less durable in treating tanks than in storage tanks and the asphaltic paints and enamels, the petroleum jellies and the cement grout appear to be more suitable for this service.

Steel tanks used in hot water boiler washing plants suffer more severely from corrosion, especially pitting and grooving, than either the storage or treating tanks. Serious corrosion has in some cases become evident after a few months' service as shown in Fig. 3 and 4 and ¼-inch plate has been completely eaten through in three years' time.

The quality of the water, especially in the wash out tanks, and the high temperatures make the problem of protecting the interiors of these tanks

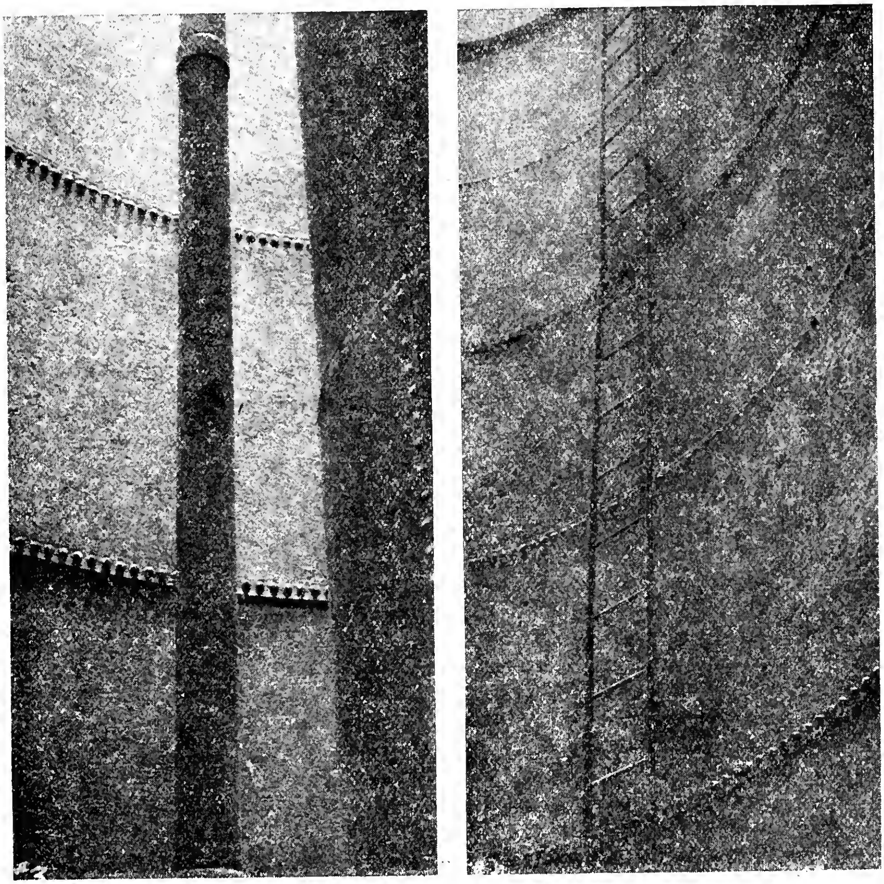


Fig. 1—Two Views of Interior of Treating Tank Built in 1910; Painted 1918 with Cement Grout. This Photograph Was Taken in October, 1923

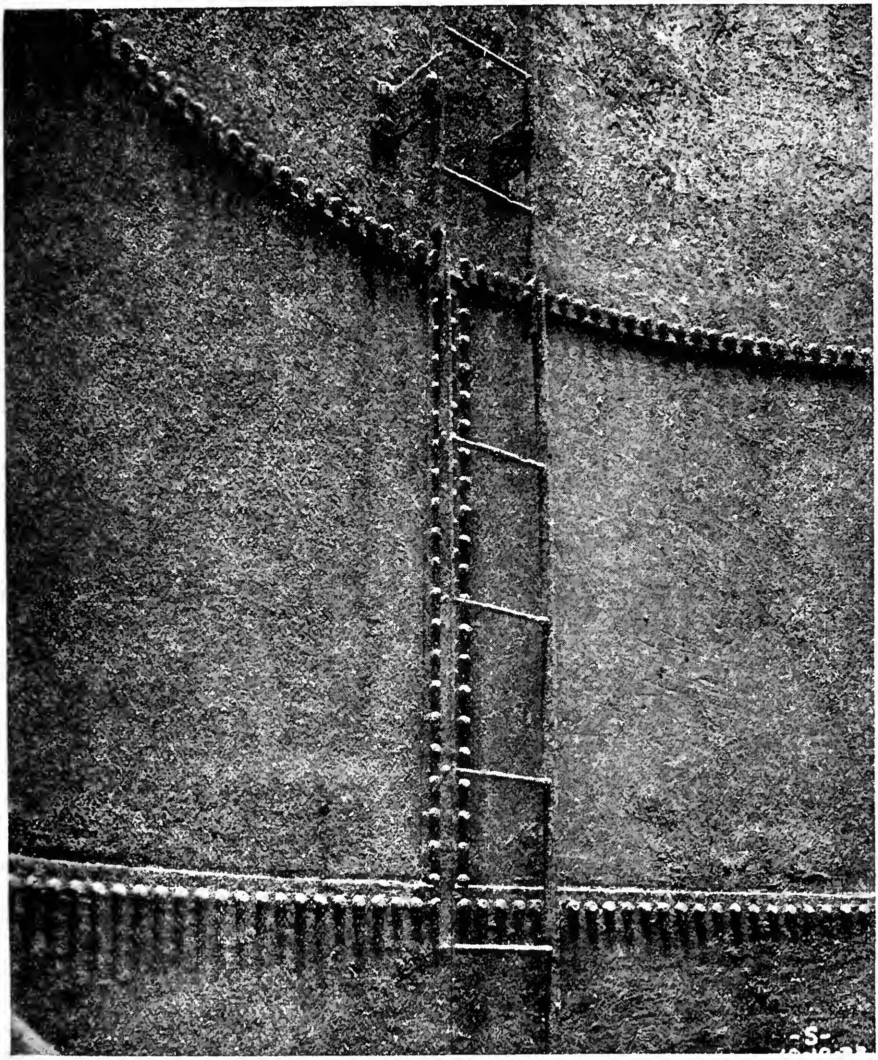


Fig. 2—Interior View of First, Second and Third Courses of Same Tank as Shown in Fig. 1

Fig. 3—Inside of Bottom of Boiler Washing Tank After Ten Months' Service. Before Being Placed in Service This Tank Had Been Given Two Coats of Paint Especially Recommended by the Manufacturer for This Service

very difficult. The paints using linseed oil as a vehicle are practically worthless in this service and many of the asphaltic paints have been tried without good results. The mastics will not successfully withstand the high temperatures encountered. The material composed of petroleum jelly with rust inhibiting chemicals has been used with success in at least one instance and offers possibilities warranting further test applications.

The use of cement grout has also proven to be of value. Two new boiler washing tanks painted two years ago with neat Portland cement grout are now in practically perfect condition excepting the underside of the roof or cover. The grout has mostly scaled off of the cover due, perhaps, to the vibration of this part of the tank. Fig. 5 and 6 are photographs of the interior of one of these tanks. One of the advantages of the use of cement grout is that any small defective places can be easily detected and patched. In applying the grout to the two tanks described above, one coat was first applied and then a small jet of steam was allowed to entered the tank, keeping

FIG. 4—STEEL PIPE INSIDE OF BOILER WASHING TANK. ALTHOUGH TWO COATS OF PAINT ESPECIALLY RECOMMENDED BY MANUFACTURER FOR THIS SERVICE WERE APPLIED WHEN PLANT WAS PLACED IN SERVICE, THE PIPE WAS PITTED AS SHOWN HERE IN TEN MONTHS

the cement moist until it obtained its final set. The second coat was then applied and kept damp with the small steam jet for ten or twelve hours before tank was placed in service.

Conclusions

1. For the interior of storage and treating tanks, paints using linseed oil as vehicle require too long a drying period and do not afford protection long enough to be satisfactory. They are unsuitable for hot water boiler washing tanks.

2. Asphaltic and coal tar liquid paints of proper composition have proven more satisfactory in storage and treating tanks but many have failed in hot water boiler washing tanks.

3. Mastic materials composed chiefly of asphalt and coal tar pitch when applied hot in layers of $\frac{1}{16}$ inch to $\frac{1}{8}$ inch in thickness over a proper

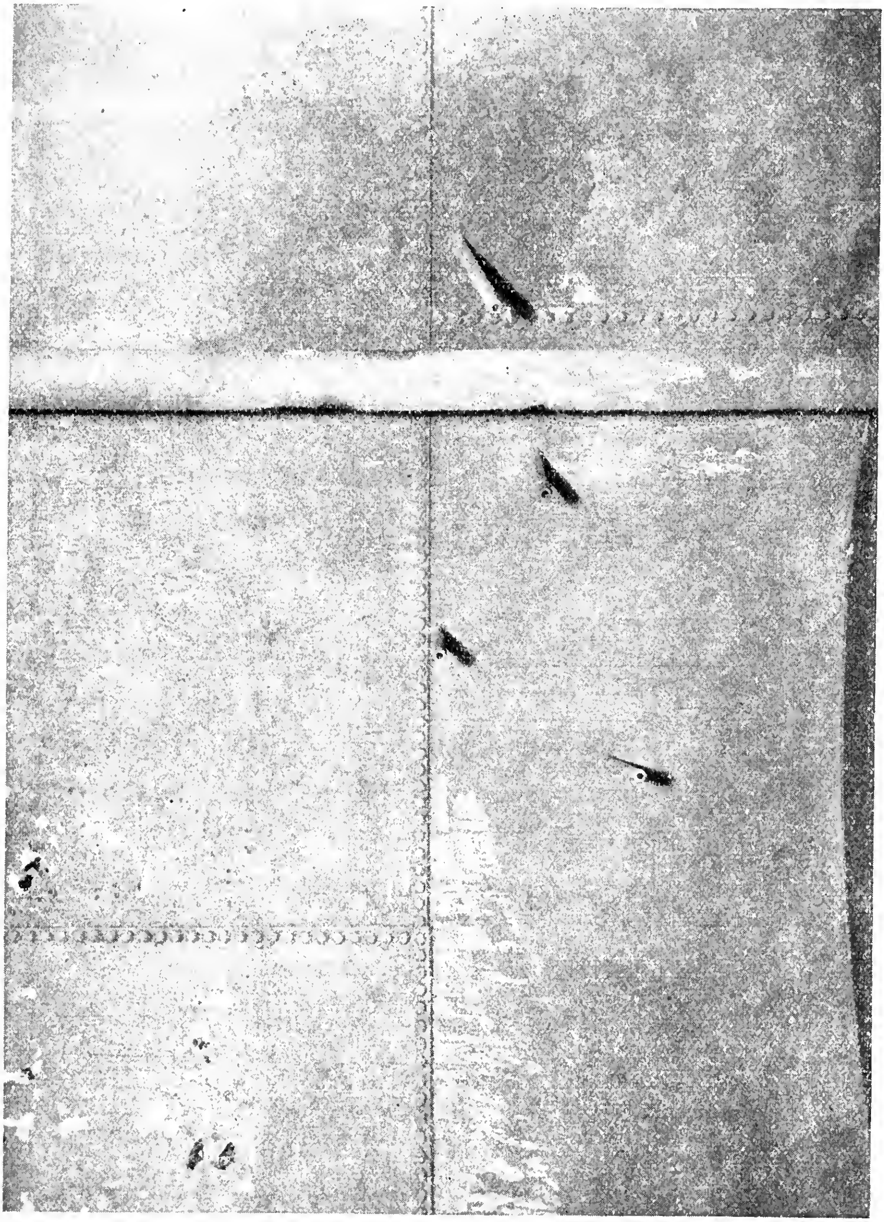


Fig. 5—Interior View of Boiler Washing Tank Taken May 15, 1928. This Tank Was Coated with Two Applications of Neat Portland Cement Grout Before Being Placed in Service November 1, 1926

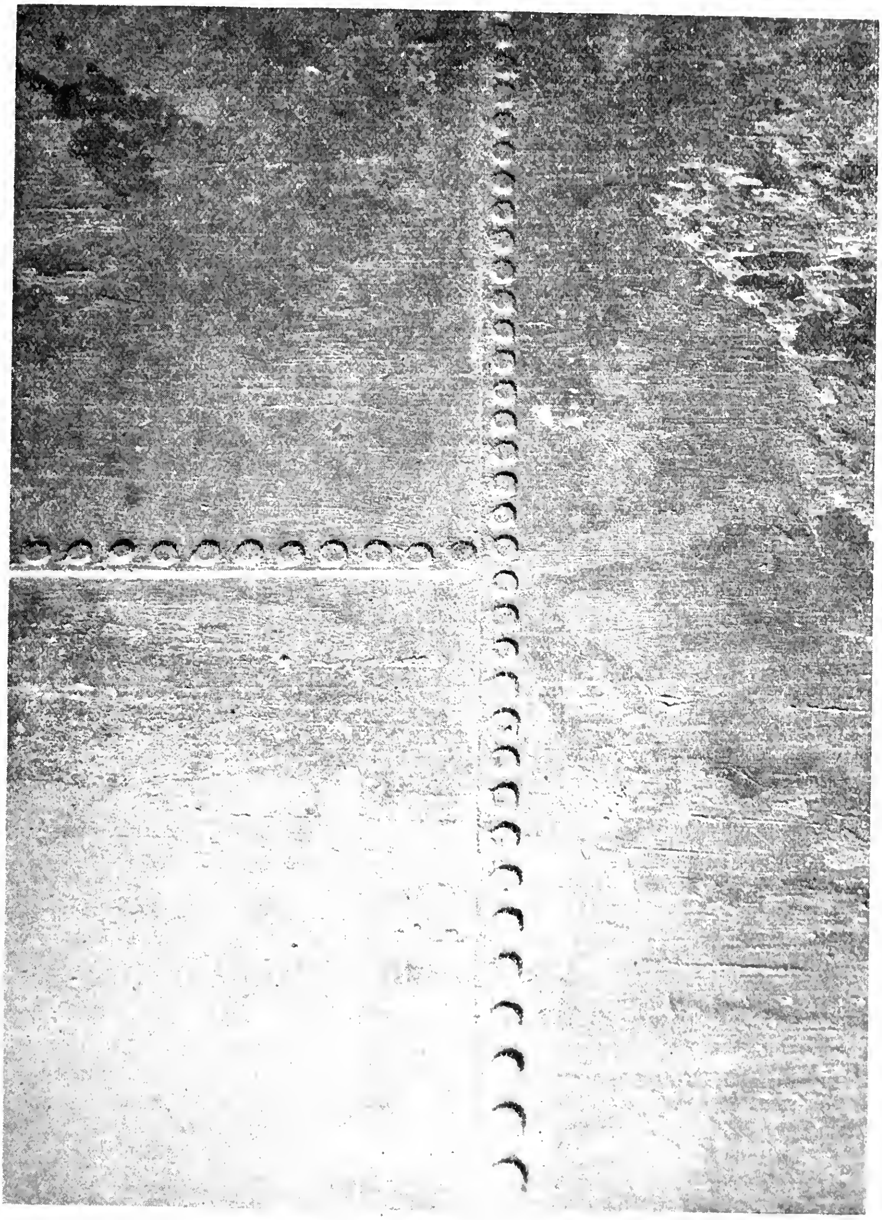


Fig. 6—Close-Up View of Interior Surface of Same Tank as Shown in Fig. 5

primer have proven very satisfactory in cold water but will not stand up in boiling water.

4. Preparations of a petroleum base resembling vaseline into which rust inhibiting chemicals have been compounded, have been used with good success in storage, treating and boiler washing tanks.

5. Portland cement grout has proven very successful as a protective coating for the interior of storage, treating and boiler washing tanks.

PROTECTIVE COATINGS FOR UNDERGROUND PIPE LINES

Steel pipe laid underground usually is corroded rather rapidly. The rate of corrosion depends upon the character of the soil and the ground water.

The life of such pipe can be materially lengthened by applying some protective coating.

The coatings most commonly used are:

(1) Paint.
(2) Bituminous, dipped or poured.
(3) Bituminous, reinforced with fabric.
(4) Petroleum jelly base preparations.
(5) Portland cement.
(6) Metallic.

In general, red lead, zinc and graphite paints mixed with linseed oil are not suitable for underground use. Paints with a coal-tar or asphaltum base are most frequently used and have given better results. One coat of paint is not sufficient to protect the metal for any considerable length of time except in very slightly corrosive soils. Paints reinforced with some filler such as asbestos fibre so that a thicker coating may be applied are more desirable. To be of practical value against underground corrosion, a non-porous coating of substantial thickness is required. Pipe protected with paint will probably last two years longer than unprotected.

Bituminous coatings consist of refined coal-tar pitch and asphalts with various fillers. These coatings are applied either by dipping, pouring or mopping. Dipping is done at the pipe mill in a tank of hot compound. Single dip coatings average about $\frac{1}{32}$ inch in thickness and are only suitable for mildly corrosive soil. In applying a bituminous coating in the field, the pipe is first given a priming coat of the same base as the outer coating and allowed to dry. The outer coating is then poured on top of the pipe and the surplus that drains off the pipe is caught in a canvas sling under the pipe. The sling is then brought in contact with the bottom and sides of the pipe and is pulled up and down, so that the pipe is uniformly covered with the material. In this way a coating may be applied up to $\frac{1}{4}$ inch in thickness. Such coatings will extend the life of the pipe from three to four years.

When corrosive conditions are severe, bituminous coatings can be reinforced with a fabric, such as burlap, rag felt or asbestos felt which will improve their resistance to abrasion and corrosion.

Reinforced coatings may be applied at the pipe mills or in the field. Application at the mill affords better control or materials and inspection, but the coating is subject to injury, especially in laying screw pipe and in shipping. An additional wrapping must be made in the field at the coupling or weld after the pipe is laid.

When reinforced coatings are applied by hand in the field, the pipe is first given a priming coat and allowed to dry. Next a coating of asphalt or coal-tar cement is poured or mopped over the entire circumference of the pipe. While this coating is still hot, the fabric is wound around the pipe and the lapped joints sealed with the cement. Over the wrapping, another coating of cement is applied. In this manner, two and sometimes three layers of covering material may be applied. Reinforced bituminous coatings may be expected to prolong the life of pipe from five to seven years.

Good results have been obtained in protecting pipe lines against corrosion by the use of a preparation of petroleum base, into which rust inhibiting compounds such as chromium salts have been introduced. It is non-hardening, resembling vaseline or axle grease and is made in several degrees of consistency.

To be effective, it should be protected by a fabric wrapper and the application is made in a manner quite similar to the process above described for reinforced bituminous coatings. However, as the petroleum jelly does not have to be melted, it is swabbed on and distributed over the pipe, its application being easier than in the case of reinforced bituminous coatings and also cheaper.

A good rich grout of Portland cement properly applied is the most permanent protection against underground corrosion yet devised. The cement grout is most economically applied with the use of steel forms in which the pipe has been centered. A grout consisting of one part of cement to two parts of clean sand is thoroughly mixed and poured into the forms, so that the coating will be about two inches in thickness. A bituminous priming coat should be applied first to the pipe. This type of protection is very expensive. Oil pipe lines in salt marshes have been protected in this way for over twenty-five years with but little maintenance.

The metallic coatings commonly used for protecting pipe lines against corrosion are zinc and lead and are applied at the mills. In general, better and more economical results can be obtained with non-metallic coatings than with metallic coatings for underground pipe line protection.

Summary

A rough estimate of the increased life in years that may be expected by the use of the coatings described above and a comparison of the unit cost of each, taking paint as the basis, is given below:

Coating Used	*Increased Life in Years*	*Unit Cost*
Paint coatings	2	1
Bituminous coatings	4	4
Bituminous coatings, reinforced, wrapped	5-7	6-9
Petroleum jelly base compound, wrapped	5	5
Metallic coatings	4	15
Portland cement coatings	20	30

The application of protective coatings to underground pipe lines is a question of economics and if choosing a coating for any particular location, the various factors such as permanency of the line, importance of uninterrupted service, accessibility, character of soil and cost of protection should be carefully considered.

Appendix E

(5) STUDY AND REPORT ON INCRUSTATION IN PIPE LINES AND METHODS OF PREVENTION PARTICULARLY WHERE TREATED WATER IS USED

E. M. Grime, Chairman, Sub-Committee; C. M. Bardwell, R. W. Chorley, C. H. Fox, L. O. Gunderson, J. P. Hanley, J. R. Hickox, R. L. Holmes, S. C. Johnson, W. B. McCaleb, S. B. Mitchell, R. W. Savidge, J. B. Wesley, A. E. Willahan.

Incrustation of pipe lines is a difficulty commonly encountered in practically all sections of this country. Where incrustation takes place in lines conveying raw water it is usually due to lack of filters or other means for removal of the solids held in suspension, but when it occurs in lines conveying water which has been softened for boiler use, it is a very different problem and one which is involved with the chemical constituents of the raw water and the treatment employed for softening purposes.

In softening water required for locomotives, using the standard lime-soda cold water process, it is usually impracticable to bring the average treated water hardness below 1½ to 2 grains per gallon. As a rule this remaining hardness is due to calcium and magnesium compounds, the composite solubility of which is about three-fourths of a grain, and therefore under ideal conditions there usually remains in the treated water three-fourths to 1¼ grains of calcium and magnesium compounds which may eventually be precipitated. Experiments have shown in some cases that even though such waters be given an extended period for settlement, this residual hardness does not come down, and yet, when the water is pumped through a pipe line, part of the hardness will crystallize out and adhere to the interior of the pipe. Analyses of sludge taken from pipe lines carrying treated water usually indicate a high percentage of calcium carbonate, with frequently some magnesium in the hydrate and carbonate forms, and a small percentage of silica.

Widely differing local conditions covering quality of the raw and softened water, and also the volume, pressure, and temperature of the water pumped affect the rate of incrustation and make comparisons difficult, but the following examples may be of interest:

1. *Wynne, Arkansas, 1200 feet of 12-inch and 14-inch line conveying softened water 18 years has ⅛-inch incrustation. Water is secured from a well, average winter temperature 50 degrees or higher. Average hardness of raw water is 20 grains of which about 3 grains is sulphate. Hardness of the softened water averages 3½ grains while there is a sodium caustic alkalinity of 1.2 grains and monocarbonate alkalinity of 4.8 grains per gallon.

2. †Painted Robe, Montana, 14,000 feet of 6-inch pipe line conveying softened water 11 years and to date has given no trouble and presumably

*Wynne, Arkansas—Missouri Pacific Railroad.
†Painted Robe, Montana—Great Northern Railway.

there is very little, if any incrustation. Pumping pressure is 95 pounds. Water is secured from a reservoir fed by a small stream. Hardness of the raw water varies from 58 to 82 grains of which 45 to 64 grains is sulphate. Hardness of the softened water averages 1½ grains while the sodium caustic alkalinity is 7 and monocarbonate alkalinity 4 grains per gallon.

3. ‡Gantz, Minnesota, 17,000 feet of 10-inch line conveying softened water shows a slow but steady growth of incrustation. Pumping pressure is 75 pounds. Water is taken during the summer months from a small stream and in winter, when practically no water flows in the stream, from storage reservoirs which have been filled during the summer. Winter conditions are severe and temperature of the water varies from 33 to 39 degrees Fahr. Hardness of the raw water varies from 21 to 66 grains of which 7 to 30 grains is sulphate. Hardness of the softened water averages 2 grains while the sodium caustic alkalinity is 6.8 grains and monocarbonate alkalinity 4 grains per gallon. This water has always been difficult to treat, presumably on account of the presence of organic matter which retards chemical action. Excess treatment as well as sodium aluminate is employed to hold the water down to minimum hardness and the plant is given close chemical supervision.

A comparison of these three cases is as follows:

(1) Lack of serious incrustation is due to a comparatively short pipe line of large size operated under low pressure. Also the warm temperature of the water, its comparatively low hardness and regularity of quality as well as freedom from organic matter are contributing factors.

(2) Lack of incrustation is quite remarkable considering the pressure used and length of service and can only be attributed to regular treatment of excellent quality and lack of any organic matter to retard chemical action. The velocity of flow is 2.2 feet per second.

(3) Here conditions are extreme as regards temperature and the presence of organic matter. In the winter season the low temperature of the water makes complete softening at the plant difficult while the slight increase in temperature as the water enters the underground pipe line will tend to cause further chemical reaction and consequent incrustation of the pipe walls. The velocity of flow through this line after it has been cleaned is 1.76 feet per second.

Incrustation is generally uniform as to distribution on the interior of the pipe except at bends and other fittings where it is thicker, and if there is any sand or grit pumped with the water a slight depression may exist along the bottom section of the pipe. Any slight obstruction in the line seems to be conducive to the accumulation of incrustation and a few strings of hemp hanging down at a pipe joint have been seen to accumulate sufficient sludge formation to almost fill a 10-inch line, whereas the incrustation averages about ¾ inch elsewhere. This may indicate that excessive pressure causes the solids to crystallize out more rapidly than is normally the case.

‡Gantz, Minnesota—Northern Pacific Railway.

As a rule incrustation is most heavy near the pump and gradually thins out as the distance increases. In general we may say that the amount of deposit is a direct function of the residual hardness in the softened water and the volume of water pumped through the line. Data is available showing that pipe lines in use at least five years where the water is maintained at 1 to 1½ grains hard apparently give no indication of incrustation.

While it is possible by the introduction of carbon dioxide gas to fix the chemical content of the water so as to avoid the possibility of after-precipitation, some engineers consider this to be unwise because the low pH value resulting will accentuate corrosive conditions if present to any extent in the original water. There are probably few cases on railroads where the cost and maintenance of the apparatus for providing the carbon dioxide would not exceed the cost of cleaning the main. There are cases where by the addition of iron sulphate, alum or sodium aluminate it is possible to reduce the temporary hardness to 1 grain or even less, and under such conditions there is practically nothing left in the softened water to come out and form incrustation in cold water lines. It is quite important that the treatment be kept regular as a mixture of undertreated and overtreated water will tend to produce the incrusting material.

Where zeolite softening is used no incrustation in supply lines occurs. This may be expected since the base exchange method of softening makes no change in the alkalinities which tend to produce precipitates.

In some cases softened water is passed through a sand filter before it enters the pipe line and the incrusting material is thus collected on the sand grains of the filter instead of in the pipe.

With the exception of occasional trouble with water column valves no record is found where there is any difficulty with comparatively short but large diameter mains where the flow is intermittent as; for instance, between storage tanks and water columns. It seems likely that the high velocity in these places continually flushes out any precipitate before it has an opportunity to cling to the surface of the pipe. This refers only to places where complete water softening is done and does not include partial softening by soda alone where the carbonates remain in the water and in some cases cause excessive pipe line incrustation. Practically all railroads report incrustation of small pipe lines supplying hot softened water for boiler feed lines at stationary plants.

Conclusions

1. Incrustation in pipe lines conveying softened water is a function of residual hardness in the water. Softening of the water which will make a reduction to one grain or less either by excess lime-soda treatment, zeolite treatment, or other methods will therefore reduce incrustation to the minimum if not entirely prevent it.

2. Fixing of the water by use of carbon dioxide gas will prevent after-precipitation but as a rule will not be justified in railroad practice and if not given very close chemical supervision may produce unfavorable results.

3. Water softening plants should be located as close as practicable to the point of consumption and thereby decrease the possibility of pipe line trouble. In large yards where raw water is available at several places individual softening plants at two or more points may be the best solution to avoid long pipe lines subject to incrustation. Automatic and remote control electrical devices may be employed to reduce attendance charges. Under favorable conditions a small semi-automatic softening plant may be built at less cost than a mile or two of large size supply pipe line.

4. The cleaning of large pipe lines incrustated from conveying softened water is usually best accomplished by the mechanical method of passing some type of cleaner through the line aided by the pressure of water from the pump and will vary in cost from fifteen to fifty cents per foot depending largely on local conditions. The cleaning of smaller mains, 8 inches and under, particularly where there are no long straight runs has been handled to advantage by pumping through the line, until the precipitate is entirely dissolved, a solution of hydrochloric acid to which an inhibitor has been added to prevent corrosion of the pump or piping. The Chestnut, Oak, and also Spruce Extract have been used as inhibitors and there are several patented products on the market suitable for the same purpose. Some of the inhibitors have poisonous qualities, and if the pipe conveys water used for drinking purposes, care should be taken to be certain that the cleaned line is thoroughly flushed out before it is placed in service. Where incrustation is largely the result of suspended matter in the water, it has been found advisable to install blowoff valves for periodical flushing at the low points or dips where the line tends to fill up most rapidly.

Note.—For further data on extent and effect of incrustation in pipe lines refer to Appendix C, Water Service Committee Report, page 413, Volume 22, A.R.E.A. Proceedings.

Appendix F

(6) REPORT ON THE USE OF GRAVITY AND PRESSURE FILTERS

D. A. Steel, Chairman, Sub-Committee; R. W. Chorley, W. L. Curtiss, J. P. Hanley, P. M. LaBach, W. B. McCaleb, S. B. Mitchell, W. B. Nissly, A. B. Pierce, H. H. Richardson, R. W. Savidge, R. A. Tanner, W. O. Towson.

Filters in water engineering are artificial facilities or works built to remove suspended matter from water by imposing a positive obstruction to its passage. As devices of clarification they are distinguished on the one hand from facilities whose process of clarification depends upon settlement and should not be confused on the other hand with filtration obtained naturally as by digging underground tunnels or wells. Filters for railway water supplies are divided into sand filters and excelsior filters in accordance with the material of which the filtering medium is made. Sand filters are divided into slow and rapid sand filters in accordance with the relative speed of filtration obtained with each type, and the rapid sand filters are divided into gravity and pressure types. In the gravity type, the force of filtration is confined to that produced by the head of the water actually on the filter bed which is exposed to the atmosphere. In the pressure type, the filter bed is enclosed so that pressure in excess of the head of water on the filter bed is possible. Because of this difference in construction, gravity and pressure filters are also commonly identified as open and closed types, respectively, while the closed or pressure types are classified as vertical or horizontal, respectively, depending upon whether the cylinder containing the sand is installed in a vertical or horizontal position.

HISTORICAL

The first sand filters were of the slow type, a name adopted after the introduction of the rapid type. They consisted essentially of a bed or beds of sand with under-drains to draw off the filtered water. In 1829, the Chelsea Water Company of London sought to remove turbidity from its supply in this manner. The results were successful and filtration of all water supplied to London from streams was made compulsory by 1855. This form of filtration was recommended for St. Louis in 1869. Poughkeepsie, N. Y., took it up in 1872, and Hudson, N. Y., in 1874. Modern bacteriology was introduced in 1885 and with the increasing success obtained in removing bacteria as well as turbidity by filtration, the construction of filtration works for municipal water supplies spread.

The rapid sand filter was born of attempts to secure the results of slow sand filtration with less investment. Slow sand filtration is a question of acreage; rapid filtration, a question only of feet. The reduction in area is accomplished by the use of coagulating chemicals and by sand washing arrangements whereby the filter sand can be cleaned thoroughly and quickly without suspending operations over a considerable period to scrape if not to replace the sand layers.

Early examples of the rapid filter or mechanical filter as it was originally designated, by reason of the mechanical washing, were used in the manufacture of paper and an installation for public water supplies was made at Summerville, N. J., in 1885. Modern rapid filtration, however, appears to have begun with experiments at Providence, R. I., in 1893 and with investigations at Louisville and Cincinnati in 1895 and 1897. The first filters of this type were circular wood tubs. Later the enclosed steel tanks or pressure type units were introduced. The use of rectangular tanks of concrete was introduced at Little Falls, N. J., in 1903.

RAILWAY FILTRATION

By questionnaire, the committee has obtained considerable data on the use of filters in railway service. A portion of this information is summarized in Tables 1 and 2. A total of 15 railroads, reported 5469 water stations furnishing 122,400,000,000 gallons of water annually. A total of 861 of these stations is equipped with water softening facilities, comprising 467 lime-soda plants, 241 soda-ash plants, 31 zeolite plants and 127 other types, treating 30,597,000,000 gallons of water per year or 25 per cent of the total pumped. The filters operated by these roads are limited to 134 installations of which 66 are excelsior filters, 6 are sand filters for drinking water, 53 are sand filters for water softeners and 9 are sand filtration plants for untreated water. Of the 68 sand filters, 33 are gravity type units and 35 pressure types. Various types of tanks and construction material are represented.

The filtration results of installations made to condition water for drinking purposes were reported uniformly satisfactory. One road operating a filter to clarify untreated water for boilers reported good results. A second road reported variable results and a third reported unsatisfactory results. Two of five roads using excelsior in connection with softening plants report unsatisfactory results, one road reports fair results, two roads report good results, while three other roads in the canvass report the abandonment of such filters. The road operating the largest number of sand filters for water softening reports satisfactory results in clarification and credits its sand filters with slight softening action. The latter results, however, have not been verified on other roads using sand filters. It is the consensus of opinion of the roads canvassed that filtration is not absolutely necessary for railway water supplies, but may be effective in reducing after precipitation.

FILTER EXAMPLES

Examples of filters operated by railroads and the results obtained from them are found in descriptions furnished the committee. The Missouri-Kansas-Texas operates a pressure type sand filter at Fallis, Okla., which was installed in 1916 for the purpose of removing suspended matter from

TABLE 1—RAILWAY WATER TREATMENT STATISTICS—SELECTED RAILWAYS—1928

		Total Annual Consumption Million Gallons		Wayside Softening Plants					Filters in Use		
Road	Water Stations	Untreated Water	Treated Water†	Lime-Soda	Soda	Zeolite	Other	Total	Sand	Excelsior	Total
B. & O.	457	1,200	570	68	14	8	....	90	3	4	7
C. M. St. P. & P.	700	3,950	1,250	45	11	....	16 Comp.	67	1	....	1
C. R. I. & P.	415	7,000	3,400	65	18	....	40 Al.	123	....	....	....
C. & O.	212	7,250	2,550	28	7	....	....	35	....	9*	....
H. V.	32	1,250	750	8	5	....	....	13	....	7	7
G. N.	460	4,300	1,200	69	1	....	....	70	1	15*	1
M.-K.-T.	144	2,550	1,500	41	44	....	....	85	2	1	3
I. C.	350	14,000	2,000	36	....	....	....	36	43	....	43
N. P.	281	3,500	350	8	....	....	....	8	....	....	....
Penna.	1,051	47,450	8,950	17	18	....	64	99	9	....	9
St. L.-S. W.	73	1,340	222	6	7	....	....	13	1	....	1
S. P.-P. L.	533	15,950	2,375	8	....	19	4 Comp.	31	2	....	2
T. & P.	107	2,035	480	14	4	1	3 Comp.	22	....	8	8
U. P.	520	7,375	2,100	54	....	3	....	57	6	46	52
Wab.	134	3,250	2,900	....	112	....	....	112	....	....	....
TOTAL	5,469	122,400	30,597	467	241	31	127	861	68	66	134

*Discarded.
†Does not include internal treatment with chemicals introduced after water is delivered to locomotive.

TABLE 2—SAND FILTERING STATISTICS—SELECTED RAILWAYS—1928

Road	Number	Type	Size	Material	Sand Bed	Installed	Water	Results
B. & O.	3	1 Gravity 2 Pressure	....	1 Concrete 2 Steel	....	1925 1927	Treated Untreated	Good Good
C. M. St. P. & P.	1	Gravity	2 Tanks 7′ dia.	Steel	....	1918	Treated	Fair
G. N.	1	Gravity	2 Tanks 18′ dia.	Wood	30″ Sand 24″ Gravel	1927	Untreated	Varies
I. C.	43	27 Gravity 16 Pressure	6′ to 18′ dia. 6′ to 18′ dia.	26 Wood 1 Concrete 16 Steel	36″ Av.	1906-26	1 Untreated 42 Treated	Good
M.-K.-T.	2	2 Pressure	8′ dia., 12′ long 8′ dia., 28′ long	Steel	48″	1916	Untreated	Poor
Penna.	9	2 Pressure 7 Pressure	14″ dia., 4′ high 8′ dia., 16′ long	Cast Iron Steel	48″ 14″ to 16″ Sand 12″ to 18″ Gravel	1911 1906-11-26	Drinking Treated Treated	Good Good
St. L.-S. W.	1	Pressure	....	Steel	....	1921	Drinking	Good
S. P.-P. L.	2	Pressure	6′ dia., 7′ 6″ long 6′ dia., 10′ 6″ long	Steel Steel	42″	1927	Treated	Good
U. P.	6	3 Gravity 3 Pressure	....	Wood Steel	30″	1917-27	3 Raw Boiler 3 Drinking	Good
TOTAL	68	33 Gravity 35 Pressure	....	2 Concrete 30 Wood 34 Steel	....	....	6 Drinking 9 Untreated 53 Treated	....

A

untreated water. The plant consists of a steel sedimentation tank 8 feet diameter and 40 feet long and a pressure filter 8 feet diameter and 12½ feet long. The cost was approximately $5,000. The filter bed is approximately 4 feet deep and consists of graded gravel and crushed quartz. At present, the water is treated with lime-soda and alum at the rate of 20,000 gallons a day. The filter improves the water somewhat, but is no longer considered necessary.

At Smithsville, Texas, the same road has another pressure type installation comprising a steel settling tank 8 feet diameter and 28 feet long. This filter was constructed in 1916 to clarify muddy river water. It has a rated capacity of 300 gallons per minute and cost $6000. This plant is now being operated as a softener. The softening and clarifying are not satisfactory and the unit is to be replaced by softening facilities providing storage sufficient to make filters unnecessary.

The Pennsylvania operates three pressure filters at Pittsburgh and four at Logansport, Ind., in connection with lime-soda softeners. The Pittsburgh filters are 8 feet diameter and 16 feet long. The filter beds are composed of 16 inches of sand and 12 inches of gravel. The filters are operated at 3 gallons per square foot per minute, filter 62,500 gallons per hour and 1,200,000 gallons per day. At Logansport the filter beds are composed of 14 inches of sand and 18 inches of gravel and water is filtered at the rate of 4 gallons per square foot per minute producing 30,000 gallons per hour and 600,000 gallons per day. In both cases, the filters reduce after-precipitation and their operation is reported satisfactory.

The Central of Georgia has recently constructed a filtration plant at Macon, Ga., to clarify raw water. The water is conveyed by centrifugal pumps to a reservoir and thence to a settling basin where coagulant is added. From the settling basin the water flows to one or the other of two rapid sand filters, each 13½ feet wide by 20 feet long, having a capacity of 540 gallons per minute, and filtering 1,500,000 gallons per day.

The Illinois Central operates the largest number of sand filters in service on a railroad. Of 43 sand filters, 42 are adjuncts of four intermittent softeners and 32 continuous softeners. Of these filters, 16 are pressure type and 26 gravity type. The filter tanks are made of steel in 15 instances, of concrete in one instance, and wood in 26 instances, and they vary from 6 feet to 16 feet diameter. The filter beds are composed of sand and gravel, built to a depth of 26 inches. These filters cost from $2000 to $8000 and are operated at the rate of two gallons per square foot per minute. All the filters are reported to be giving satisfactory results. The cost of operation and maintenance is approximately one per cent of the cost. The wash water is reclaimed and the filtration removes suspended matter in the water and effects a reduction in the hardness of the treated water from one-half to one grain per gallon.

ADAPTABILITY TO RAILWAY SERVICE

The primary object of filtration is to remove suspended matter from water. The committee finds that properly designed and operated sand filters

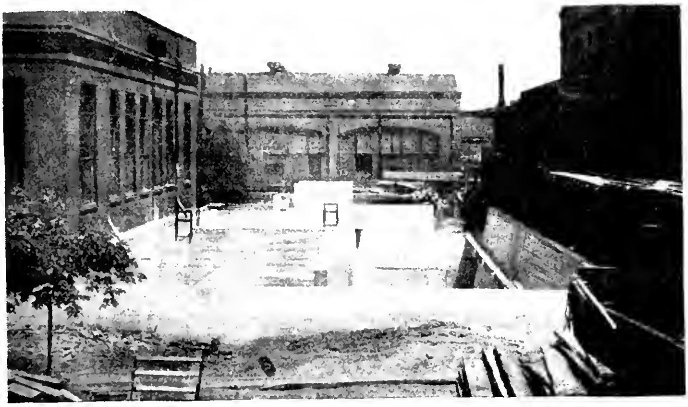


FIG. 1—FILTER PLANT CONSTRUCTION, CENTRAL OF GEORGIA RAILWAY

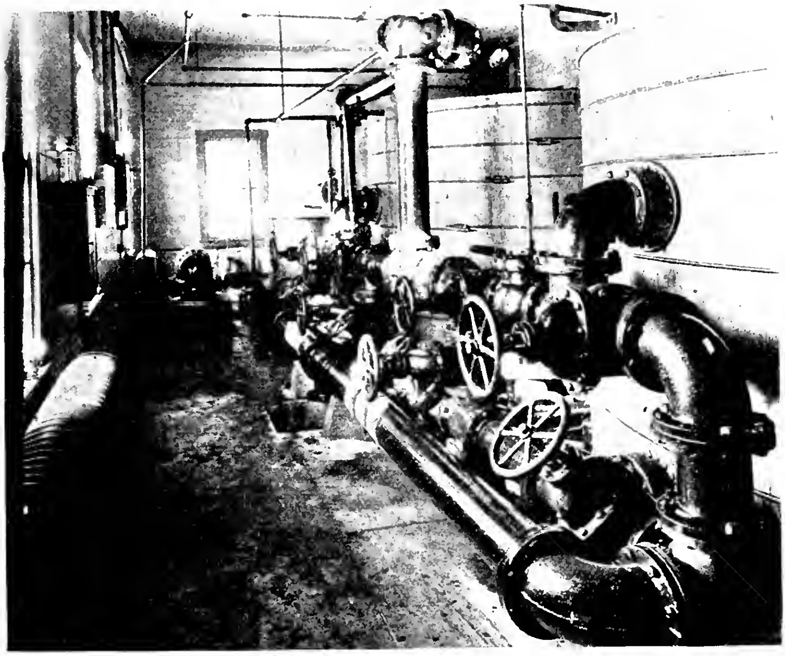


FIG. 2—GRAVITY TYPE FILTERS, ILLINOIS CENTRAL SYSTEM, DIXON, ILL.

will accomplish this purpose. They will also reduce bacteria and under some conditions, will slightly reduce the hardness of treated water. By removing mud and other suspended material which might otherwise enter the boilers and by reducing after-precipitation in pipe lines, boiler feed pipes, etc., such facilities can often prove economical. While not recommended as a substitute for sedimentation they can sometimes be utilized to reduce the cost of such facilities and should be seriously considered in all cases of turbidity in untreated boiler water and where water treating facilities fail to produce a completely settled effluent at all times.

Your Committee does not wish to be misunderstood. It does not recommend the indiscriminate installation of filters to correct water troubles.

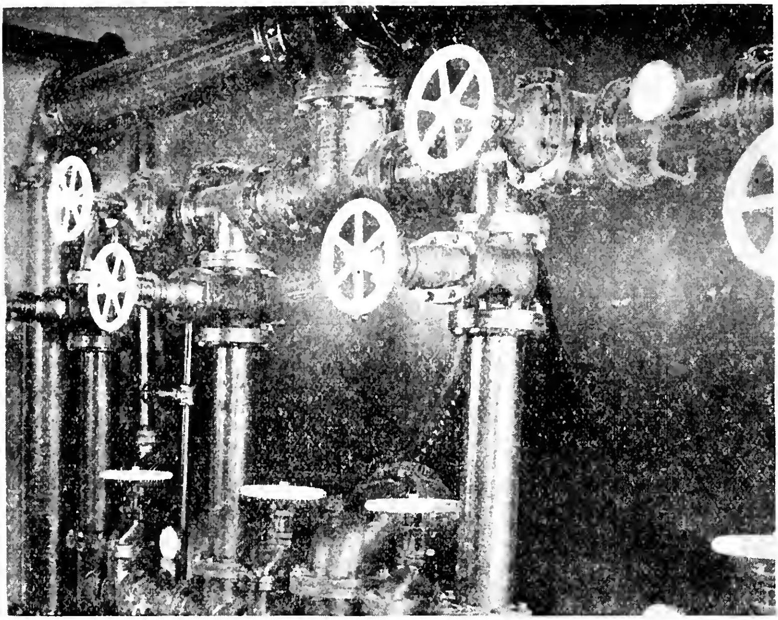


FIG. 3—HORIZONTAL PRESSURE FILTERS, ILLINOIS CENTRAL SYSTEM, IOWA FALLS, IOWA

Where the removal of disease organisms is not involved, the installation of filters is frequently not justified and in connection with sanitation, filters are not a security against disease caused by micro-organisms without disinfection and laboratory control.

In connection with water supplies for boiler use and particularly in connection with water softening processes, filters may frequently be an unnecessary expense and even a detriment, depending upon the conditions they are made to meet, the designs employed and the attention given to their operation. A poorly or incompletely designed filter is a waste; efficient filters cannot be expected to correct wholly inefficient water softening and indifferent operation and maintenance is the signal for their eventual abandonment. This is particularly true with softening facilities where filtration is usually complicated by the tenacity with which chemical percipitates adhere to the sand grains.

Your Committee, however, is impressed with the increasing importance of providing clear water for locomotive boilers at all times, and seriously questions the economy of allowing sediment or precipitates to settle in distributing systems and storage or service tanks. Aware of the frequency with which it becomes impracticable at seasons to eliminate turbidity of some natural waters within a reasonable time by sedimentation alone and of the difficulty at stages of producing, without filtration, softened water that will not settle in distributing systems, it believes filtration will frequently pay large returns on the investment and maintenance. Where clarification in softening plants is uncertain filters are a safety measure.

SETTLING AND COAGULATION

The requirements of efficient filters are adequate sedimentation, coagulation, properly constructed sand beds, correct flushing facilities and efficient drainage. Too much emphasis cannot be placed upon the importance of sedimentation and coagulation. It is exceptional when successful filtration can be obtained without them. The neglect to provide for them is a cause of filter failures. Ordinarily, water applied to filters should not carry more than two grains per gallon of matter in suspension. Suspended material in excess of this should be removed in sedimentation basins, settling tanks or grit chambers. All water reaching filters should have its suspended matter coagulated. This will avoid excessive flushing of the filter and secure better filtration.

The amount of suspended matter that will settle out of water depends upon its fineness. The coefficient of fineness is the weight of suspended matter divided by its turbidity, U.S. Geological Survey Standard. Where the coefficient of fineness is as high as 1.5, approximately 30 per cent of the suspended matter will settle in the first ten minutes, if the velocity of flow does not exceed 12 feet per minute. If the coefficient is 1.0 or less, a settlement of only 10 per cent is usual under the same condition.

When filtering raw water, plain sedimentation is usually sufficient, if the suspended material is reduced to 40 p.p.m. per minute after 26 hours standing, otherwise coagulants should be used to expedite the settlement, as well as to prepare the water for the filters. When coagulant is not necessary to facilitate settling, the shape of the basin is not important, but it should be deep enough to dispense with frequent cleaning and protect the water from wind and wave action. A depth of 12 feet is usually necessary.

Where coagulation is necessary in the sedimentation work, settling basins limiting the retention of the water to six hours are usually sufficient, if the flock is properly formed and the velocity does not exceed 14 feet per minute.

The ideal basin is a rectangular shaped, 14 to 18 feet deep. The water should enter the surface, move in straight lines and be drawn off at the surface. In some instances, sediment can be accomplished in settling tanks of steel or wood by vertical flow but this is not usually recommended and in all cases where a construction of this kind is adopted, it is better to pass the water through a single tank at low velocity than through a series of tanks at higher velocities.

Coagulation is accomplished by the use of various chemicals, prominent among which are alum, ferrous sulphate and sodium aluminate. The chemical generally used is alum, which will usually form a coagulant without the addition of other chemicals. When ferrous sulphate is used, the addition of lime is usually required to produce a satisfactory flock. Sodium aluminate has the feature of not increasing the sulphate hardness of water. Coagulating chemicals are applied or mixed with the water either in conduits with baffles or in mixing tanks equipped with or without agitators. Good coagulation requires complete mixing before the water leaves the mixing chamber and to avoid breaking up the flock by too violent agitation. Poor coagulation is frequently no better than no coagulation at all. The use of one grain of coagulant per gallon is generally sufficient, although the application of four grains per gallon will usually increase settlement from 25 to 50 per cent.

Where the purpose of filtration is to clarify water from a softening plant, special provisions for sedimentation and coagulation need not be made. The settling tank of the water softener is the sedimentation facility and coagulation in abundance is usually afforded by the chemicals employed in the softening process. This coagulation and sedimentation should ordinarily be designed to prove adequate without filtration. Settling troubles often result from excessive velocities and insufficient retention time. The velocity should preferably not exceed 8 vertical feet per hour and the retention no less than 5 hours. In all cases the settling facilities should be adequate to reduce the suspended matter to 3 grains per gallon before filtration.

SAND BEDS

A distinguishing feature of rapid sand filtration lies in the fact that the collection of suspended matter is not confined to the surface of the bed as in slow sand types, but is distributed throughout the sand area and that the effectiveness of the sand lies not so much in the straining action as in the physical attraction of each grain for the material coming in contact with it. The sand must be small enough to afford a maximum exposed surface to the water but not sufficiently small to restrict the flow of water through the bed excessively or wash away. Round grains are superior to sharp grains for this purpose. They should be of uniform size and should preferably consist of quartz containing nothing that will dissolve in the filtered water. The allowable size of the grains may range from an effective size of .35 to 60 mm., depending upon conditions, but should usually be less than 45 mm.

The depth of sand bed will vary with the size of sand grains used and rate of flow but should not be less than 30 inches in thickness, including one or more layers of gravel below the sand, graded to facilitate drainage and to distribute the wash water. The gravel should not be less than ¼ inch in diameter nor exceed 1¼ inches. The filtration should be limited if possible to 2 gallons per square foot per minute and under no circumstances should it exceed 4 gallons per square foot per minute.

DRAINS

A weak point of filter design frequently lies in the drainage system, which in rapid filtration is also utilized to distribute the wash water. If the drains are too large, the filter sand may be washed away; if they are too small, they may result in clogging or impair the uniformity with which the water is drained or distributed to the bed. Various designs of drains are employed in filtering practice, most of which are patented. One road is satisfied with a simple grillage of pipe drilled with holes. Others used a system of manifolds, or nozzles, while other filter systems dispense altogether with nozzles and depend upon a gravel under-stratum supported on a perforated plate. When filtering softened water, brass manifolds should be avoided because of their tendency to incrust and eventually clog.

WASHING

Sand washing is a vital feature of rapid filter operation and all plants require sufficient capacity for washing as well as for filtering. Excessive washing is expensive; insufficient washing will reduce the flow, while too vigorous washing will destroy the sand bed. Water should pass through a clean filter with only from 1.2 to 1.5 foot loss of head. This loss of head increases as the sand grains become coated and may reach 6 to 10 feet in pressure filters before flushing is required. The value of agitators or compressed air for cleaning the sand is questionable. The approved method is to force water through the filter in a reverse direction to the normal flow and with sufficient velocity to float the sand grains until the dirt is removed. Usually this requires a flow of 8 gallons per square foot to 15 gallons per square foot per minute for a period of from 3 to 8 minutes. Flushing once a day is usually sufficient. Frequently washing once a week is adequate. If the filter requires more frequent cleaning the sand may be too fine or the sand bed may require changing. The sand should not require renewal more than once a year, and should last several years. In flushing the free-board or distance from the top of the filter bed to the point of discharge is important. It will depend upon the depth of sand, the size of sand grains and the rate of washing, but should not be less than 12 inches nor more than 30 inches to protect the sand bed from scour during filtration and prevent the escape of sand during flushing. Where troughs are used to carry away the wash water, they should not be more than four feet apart. The wash water should preferably be filtered. The volume should not exceed 5 per cent of the total volume filtered and it should be reclaimed by discharging it back into the water supply. The condition of the filter can be determined by gages or floats depending upon the type of filter used, but it is recommended that all flushing of filters should be done at scheduled period.

COSTS

Typical costs of filters are shown in Table 2. They range from $2000 to $17,000 and up, depending upon the size, number of units, accessories, method of construction and quantity of water handled. Few figures are available as to the cost of maintaining filters, but usually the cost should not exceed one per cent of the cost of softening water.

GRAVITY VS. PRESSURE FILTERS

Gravity type and pressure type sand filters are both employed in railway water supply filtration. Each has its advantages and a choice must necessarily depend upon conditions. The pressure filter utilizes the head from a gravity or pressure source to distribute the water. In a gravity type, the filtered water must be collected in a clear well or collecting basin and repumped. Where conditions advise the repumping of softened water independently of filtration the value of this feature is reduced and may be offset entirely by the greater flexibility where filtered water first is drained into a collecting basin. Repumping is a positive disadvantage in small installations.

Since the gravity filter is open at the top the available head for filtering cannot exceed the difference between the level of water in the filter and that in the clear well below the filter, while the head on the pressure filter, ranging from 8 to 15 feet, can be applied to increase the rate of filtration. This may be an advantage where emergencies call for forced operations, but unless finer sand and a deeper bed are employed the degree of clarification will be less and the filter can easily be destroyed.

Pressure filtration does not require the construction of collecting basins and usually occupies less space than the gravity type. Since they are factory built with all piping valves and control work they are conveniently installed. The designs also usually reflect experience in manufacture, afford a neat appearance and are better adapted to heating. In some states the use of pressure filters for clarifying drinking water is prohibited.

The great advantage of the gravity type filter is the ability at all times to see the condition of the bed and to watch the flushing process. This is important where the operations are remotely situated and left to unskilled labor or infrequent supervision. Because of this and also because of the lower-duty at which they are operated, the gravity filters usually require less maintenance than pressure types filtering the same quantity of water. They can also be fitted to special conditions and are not subject to limitations in size. In addition they permit the introduction of water to the filter beds without breaking up the flow.

Pressure filters are built of steel tanks which may be vertical or horizontal, depending upon the capacity. The diameter should not exceed 8 feet and in all cases, it is important to specify the maximum working pressure, and to insure that all pipe fittings are flanged to allow for economical repair.

Wood or concrete is satisfactory for the construction of gravity filters. Circular tanks of wood bound with iron hoops are preferred to rectangular tanks. The advantage of wood tanks under some conditions is that they can be factory built by manufacturers experienced in filter construction and operation. The diameter of wood tanks should not exceed 18 feet for effective filtration. Where the size of the project makes construction on the ground feasible, concrete is a highly satisfactory material. Concrete tanks should be rectangular, however, and special care should be exercised in providing pipe connections to avoid leaking.

Where continuous filtration is required or the pumping exceeds 200,000 gallons per day, stand by units are recommended, otherwise, a well designed, single unit is sufficient, supplemented where necessary by storage tanks. Where freezing temperatures are encountered special care should be taken to provide adequate housing. Filter type should be constructed at ground level.

RAPID VS. SLOW FILTERS

The rapid sand filter has not completely replaced slow filtration. Properly constructed slow sand filters have proved highly efficient both in removing organic and inorganic matter. The filtration more nearly duplicates natural conditions than in rapid sand filtration. The rate of filtration is from 20 to 40 times slower per unit of area, which requires correspondingly more area to handle the same quantity of water. Filtration must be discontinued periodically while the sand beds are cleaned by scraping. Unless care is exercised in operating the filters, mud cracks will develop and reduce the efficiency of the entire bed.

It is necessary to efficient water softening that the effect of any adjustments in the treatment can be quickly obtained in the treated water. This makes it desirable to limit the volume of water in the distributing system to a minimum. Because slow sand filters would increase by 20 to 40 times the volume, this type of filter is not recommended for softened water. With untreated water, however, where adequate space and suitable sand are available at small expense, slow sand filtration deserves consideration. As in rapid filtration, however, the water should first be passed through sedimentation basins. They are not adapted to the filtration of water of high turbidity.

SAND VS. EXCELSIOR FILTERS

The use of excelsior for filtering railway water supplies has been confined altogether to water softening. It was common in constructing earlier types of continuous softeners to provide a filter of excelsior. It consisted of a mattress of excelsior 12 to 24 inches thick supported between perforated steel plates in the top of a settling tank where it was employed to remove particles of precipitate remaining in suspension as the water reached the top of the tank. A few roads report satisfactory results from such filters, but they have been abandoned in large numbers and are seldom installed in modern softeners. The fresh excelsior possesses filtering possibilities, but its effect is limited to removing, usually in part only, the suspended matter that would settle quickly in quiet water, and the low cost to renew which ranges from $30 to $80 is usually greatly offset by the obstruction they constitute to the economical operation of softening plants which demand clear passages easily inspected and maintained. Excelsior filters are occasionally justified in softeners operated beyond capacity but are seldom to be recommended.

Conclusions

1. It is increasingly important to supply clear water to boilers.
2. Properly designed and operated filters will produce clear water and reduce "after precipitation" in treated water.
3. They do not dispense with sedimentation and coagulation and are recommended only where reasonable sedimentation and carefully designed softeners fail to secure the proper degree of clarification.
4. Sand filtration is more effective than excelsior filtration.
5. Gravity type filters are usually preferred to pressure installations for large duty stations.
6. Rapid type filters are usually preferred to slow type filters for railway supplies.

Appendix G

(7) FIRE PROTECTION AND PREVENTION AT WATER STATIONS

A. E. Willahan, Chairman, Sub-Committee; F. H. Kornfeld, R. A. Tanner, H. E. Silcox, W. B. Nissly, H. F. King.

Member railroads of the American Railway Association possess water station facilities, the value of which is estimated to be $220,000,000. Of this sum $44,000,000 is the value of buildings and equipment which may be damaged by fire.

During the last five years, 671 fires have been reported. The losses chargeable to Water Stations was $377,576. To this sum must be added the loss due to interrupted service which is estimated as six per cent of the direct loss. Our total loss is, in round numbers, $400,000. The sum is not small and greater effort should be made to reduce this loss to a minimum.

Analysis of data reported by 75 railroad companies indicated that approximately 90 per cent of the loss to water stations may be attributed to the following hazards:

(1) Inadequate clearance between unprotected wood structures and the furnace or stack of boilers.
(2) Improper disposal of ashes.
(3) Accumulations of combustible material near boiler furnaces.
(4) Sparks from passing locomotives or other fires on unprotected roofs.
(5) Defective electric wiring.
(6) Forest and grass fires.
(7) Improperly maintained piping in fuel lines to boiler furnace or to internal combustion engines.
(8) Careless use of matches and open torches.

Reports show conclusively that the loss is accounted for principally by the first four hazards, about 85 per cent. If everyone concerned with the care or operation of water stations is thoroughly informed as to the seriousness of the hazards set out in the report our losses should be materially reduced.

Recommendations

Believing that loss and damage by fire can be reduced to a sum considerably less than the present amount, the following recommendations are made:

(a) Correction of structural defects involving fire hazard in present installations as early as practicable.

(b) In all new installations provision for ample space between wood walls or partitions and any source of heat such as furnaces, boilers, stacks, exhaust pipes from internal combustion engines, electrical resistance grids and stoves. For stacks on boilers, particularly when not insulated, metal thimbles should be used. The ventilating space should be not less than twice the area of the stack section.

(c) Use of fire-resistive roof materials on all wood structures.

(d) Careful construction of fuel piping with frequent inspection.

(e) Electric wiring to be installed in metal conduit and subject to thorough inspection before put in use.

(f) Thorough inspection relating to and enforcement of the proper care of premises and equipment.

(g) Provision of fire extinguishing apparatus most suitable for the building and contents. Any or all of the following may be provided:

(1) Sprinkler Systems automatically controlled.
(2) Fire Hydrants and Hose from a tank or fire pump supply.
(3) Chemical Fire Extinguishers.
(4) Fire Buckets and Barrels available from the outside of the buildings to be protected.
(5) Sand Buckets and Loose Sand available where fires due to Oil or Electricity might occur.

(h) Metal Containers for Oil and Waste and, where warranted, Metal Lockers for clothing.

(i) Erection of fire resistive and slow burning structures at important points of supply or where they can be economically justified.

Erection of wood buildings only in locations where a fire would result in a small loss.

(j) Investigation of, and formal report on, all fires occurring. Report of the investigation to be given to all employees of the company having jurisdiction over installations similar to that in which the fire occurred.

Appendix H

(8) REPORT ON THE DESIGN AND MAINTENANCE OF TRACKPANS FOR LOCOMOTIVE SUPPLY

E. G. Lane, Chairman, Sub-Committee; W. L. Curtiss, W. B. McCaleb, W. B. Nissly, A. B. Pierce, F. D. Yeaton.

MONOGRAPH

By W. B. McCaleb
Engineer Water Service, Pennsylvania Railroad
MEMBER OF SUB-COMMITTEE

A report on trackpans appears in Appendix A, page 892, Vol. 14, of the Proceedings of the Fourteenth Annual Convention of the American Railway Engineering Association. This report was written by the late George W. Vaughan, Engineer Maintenance of Way, New York Central & Hudson River Railroad, and is well worth reading by all members of the Association.

The following data and suggestions reflect the experience on the Pennsylvania Railroad during recent years, summarized under the respective headings.

Location

Considering the expense of construction of a trackpan station and the subsequent cost of operation, the matter of location is of primary importance. Recent studies indicate the many features affecting the matter of location and unless all of these have been considered and satisfied, the results from an operating standpoint will not be economical or satisfactory.

Our experience has indicated the necessity of actual tests on every division where the matter of trackpan installation is being considered to determine the actual water consumption of locomotives for each district and the existing operating conditions. These tests should include the various types of locomotives and trains, and should cover winter and summer conditions.

The effect on the proposed development and on adjacent stations of providing larger tenders must be considered. The effect of the increasing efficiency as regards coal consumption has an important bearing on the trackpan question, as it is resulting in an ever-increasing distance between stop for "coal and water"; fire cleaning, etc. The increasing economy in the use of water; increasing train loads, general speeding up of train movements; the benefits obtainable from 100 per cent treatment of water on a division are also important factors, together with the first cost of the layout and cost of operation at any particular point, including relative cost of the water per 1000 gallons.

When these important considerations have been satisfied, there remain certain physical requirements which must be accommodated. The pans must be located on level track, preferably on the tangent, although this latter requirement is not absolutely necessary. The location cannot be close to station or interlocking plants, owing to the wasteage. Finally, the cost of providing satisfactory drainage must be considered.

Design of Pans

The proper design details of the pans themselves is a matter that has received very careful study in considering the efficiency of any particular scheme. It is necessary to include the importance of the tender scoop as regards design, setting, maintenance, etc.

We have in service pans having nominal widths of 19 inches, 22 inches, 26 inches, and 29 inches. The depths vary from 6 inches to 7.25 inches. Some of the wider pans are equipped with lips at the top projecting into the pan, thus reducing the surface opening, i. e., in one case a pan 26 inches wide is equipped with lips resulting in a surface opening of 19 inches. For a given length, the 26-inch pan has a greater storage than would a 19-inch pan with the same surface opening.

Our Test Department has recently completed a very interesting series of tests on the various types of pans, and the following data is taken from their report.

(1) With 11,000-gallon tender the amount of water taken into the tender and the amount of water spilled are independent of the speed of the tender provided the speed is 25 miles per hour or higher. No tests were made at a greater speed than 60 miles per hour.

(2) Making a trackpan wider than 19 inches in order to provide extra storage capacity for use when there are two locomotives at the head of a train, is of value only when the track tank is so short that the first locomotive must scoop water for the entire distance. Under these conditions with our present scoop and present track tank full of water, if the tank is 29 inches wide the second locomotive will get approximately 37 per cent as much as the first locomotive, while with the tank 19 inches wide the second locomotive will get 22 per cent as much as the first locomotive.

(3) Reducing the width of the opening of the top of the track tank reduces the amount of water spilled.

(4) As the depth of immersion of the scoop is increased, the amount of water put into the tender will increase, the increase in the amount of water being somewhat less than the increase in the depth of immersion.

(5) With any given design of track tank, the amount of water spilled depends principally upon the height of the sides of the track tank above the surface of the water, the higher the sides the less the spill.

(6) A tank with inside lips and a 19-inch opening at the top will spill less water than a tank with straight sides with a 19-inch opening at the top.

(7) The best design of track tank is one having inside lips at the top with an opening at the top as narrow as practical and with the surface of the water carried as far below the top of the tank as practical.

(8) With a given design of track tank and a fixed position of the top surface of the water, the highest efficiency will be secured when the depth of immersion is greatest, provided the scoop is designed for the immersion used.

The amount of water actually taken into a tender per 1000 feet of pan varies with the coal and water load of tender, conditions of track and scoop, etc., but on the average may be assumed at approximately 2500 gallons maximum, and 2000 gallons as an average. The efficiency of the pans, i. e., the ratio of the water taken into the tender and the amount of water originally in the track pans varies from 68 per cent to 90 per cent under ideal conditions. Probable average efficiency is in the neighborhood of 65 per cent.

Where helper and pusher engines are used, the quantity taken is further affected by the pan storage, filling facilities and length.

These tests were made on a number of different installations and by using different tenders. In general all of the pans had multiple pan filling connections, automatically controlled, but in each the control connection for the automatic valves was located at the center of the pan and was common to all connections for the pan.

The matter of length is very important, inasmuch as it limits the amount of water which can be taken by any locomotive.

Practical considerations control the pan length; such as first cost, cost of maintenance, heating, ice removal, etc. In the event that it is common practice at any particular location to operate trains with two locomotives at the head end, care must be taken to satisfy the requirements for both locomotives.

The materials used in the construction of the pans; desirable joint lengths, type of joints, method of anchoring, etc., are all important.

Our present standard practice is to use pan sections 25 feet long of flange construction and spiked centrally between the rails to the ties, the joints between the respective section and the cast lead type interlocking with the end flanges on section of forming collar. This type of joint eliminates the necessity of all riveting on the pans and assures water tightness throughout. The end slope sheets are also of fabricated steel construction, thereby eliminating all wood cribbing at this point.

Another very important feature is the time of filling the pans. In general we believe this should be made as short as practicable and should not exceed four minutes under average conditions. Our experience has indicated the desirability of providing multiple inlet connections independently controlled; the connections to be at close intervals at the entrance end of the pan and on wider intervals at the run-off end of the pan. The pan filling connections should be controlled automatically by float valves properly housed to prevent freezing. The float valves to be actuated by independent connections with the pans, the lead being approximately 15 feet on the approach side of the connection. Track pan installations so controlled can be operated without regular attendants on our railroad from April 1st to November 1st, inclusive, provided arrangements are made with the trackwalker for casual inspection and reporting of any unusual failure.

The following is a list of installations on our system, giving details as to number of tracks equipped, the width of the pans, and the length:

Division	*Location*	*No. of Tracks*	*19"*	*22"*	*26"*	*29"*	
			Linear Feet of Tanks of Each Width				
New York	Rahway	6	7200				
	Plainsboro	4		6400			
	Bristol	4		3200		3200	
Trenton	Florence	2	1300	1300			
	Frenchtown	1		1300			
	Howell	1	1200				down
	Br. Mills Jc.	1	1000				down
Atlantic	Ancora	2				2400	
	Wildwood Jc.	1				1600	down
Phila. Terml.	St. Davids	4	2000	2000			
Maryland	Glenolden	4	4900				
	Ruthby	3	2600				
	Edgewood	2	2600				
Baltimore	Stony Run	3	3200				
Philadelphia	Atglen	6	6000	3000			
	Dillerville	2	1500	1500			
Middle	Bailey	4	3600	3600			
	Narrows	4	5400			1800	
	Jackstown	4		1400		5000	
	Bellwood	2		2400			
Pittsburgh	Wilmore	4		3640		5250	
	Sang Hollow	3				5400	
	Latrobe	4				7200	
Eastern	Grafton	3		1800	3600		
	Millbrook	2			3600		
Fort Wayne	Dola	2			4850		
	Davis	2			4850		

Water Storage

It is important to provide adequate water storage at the station in order to secure continuous operation. This especially true where the station is dependent on the supply brought into the station from an outlying source.

In general we recommend not less than 24 hours' supply, the storage to be adjacent to the pans in the nature of a reservoir or steel standpipe and placed preferably at the center of the pans. The storage should be so located as to give an ample head on the pan connections, and the supply pipe lines to these connections should be of liberal design in order not to sacrifice the head.

Where the water supply is pumped at the site of the pans, duplicate pumping units should be provided, and the amount of storage provided may be less. Present-day practice indicates the desirability of motor-driven equipment, automatically controlled. Where the operation is based on purchased power, some standby unit should be installed, usually steam.

Drainage

Satisfactory drainage facilities must be installed, and there are a number of excellent schemes which can be applied. Whichever scheme is adopted must be such as to permit a rapid carrying away of water wastes from the pans, including splash, overflow, leakage, and the water lost from the pans by wind action. Scouring of the ballast must be prevented.

We have on our system points where the water supply for the pans is purchased from private companies at very high rates. At these points we have found it economical to connect the drainage system with a sump, on which is mounted motor driven sump pumps. The operation of the pump is automatic, being controlled by the depth of the water in the sump. The units are housed, and they repump the waste water into the storage tubs for reuse. Such plants are also necessary at some points to protect adjacent low-lying valuable property. The salvage plants have been found satisfactory and economical.

Heating Water During Winter Season

The climate in which we operate necessitates the heating of the water in the pans during the winter season to prevent freezing. This is one of the most expensive items in connection with the operation of track pan stations. Usually the heating season extends from November 1st to April 1st.

In our case the water in the track pans themselves is circulated by means of a steam injector connected on the pan side of the automatic valve; the water simply being kept in circulation and being heated by the absorption of heat from the steam used in the injector.

Apparently little or no progress has been made toward heating the water automatically, controlling the heat with changes in temperature, as for instance automatically controlled fuel oil fire boilers.

Ice Removal

At very much exposed locations the expense of ice removal has been found to be very large. The ice forms from splash along the pans and from the drip along the tracks for some distance from the run-off end in the direction of traffic.

At important stations during protracted severe cold spells, the accumulation of ice has assumed tremendous proportions, and it was sometimes necessary to maintain gangs of one hundred men or more for removing the ice. Aside from the labor expense, the risk of fatal accident due to the icy conditions was great, and resulted in a generally unsatisfactory condition.

To reduce this expense we have installed heating lines along each rail and close thereto, and in the six feet between tracks. The lines along the rails extend the full length of pans and for a distance of 800 feet measured from the run-off end of the pans in the direction of traffic. The lines in the six feet extend for the entire length of the pan.

The ice-thawing apparatus is a closed hot water system, and operates with the water at a temperature from 150 to 300 degrees Fahr. The circulation is forced by means of two pumps, and in extreme cold weather it has been possible to make the circuit with a loss of approximately 100 degrees in temperature.

They have proved economical and satisfactory.

Cost

It is difficult to give even an approximate cost of track pan installations where all the details are not known. The cost varies with the location, number of tracks, length of pans, etc. An estimate prepared in 1917 covering construction of a new four-pan station on our Pittsburgh Division indicated a probable cost of $450,000. The estimate included necessary storage, power plant including boilers, pumps, etc., drainage system, and signaling. The estimate included no cost for change in alignment or grade. Four pans were contemplated, each pan being 2100 feet long, 29 inches wide. The estimate did not include facilities for obtaining the water, as this was to be delivered into the storage by gravity from one of our Water Companies.

Typical Layout

In common with all railroad experience in such matters, we find many theories in detail of layout and construction at our many track pan stations.

In general we find that considerable operating difficulty is experienced with inadequate pan filling facilities. These are frequently too small considering the run and head available, with the result that slow filling obtains. In some cases considerable improvement can be made in the drainage facilities at a number of points.

Formerly signal power equipment was incorporated in the power plant at track pans, in order to secure the benefit of one operating crew. The practice now seems to be towards purchased power for signal operations. This will allow, therefore, in future designs, a very much simpler layout for the track pan equipment, i. e., boilers, pumps, etc.

Maintenance

The amount and cost of maintenance is influenced tremendously by the care taken in the location, design and construction. Proper maintenance includes maintaining the pans level throughout their length, cleaning of the inlet ports and the lead connections for the float valves. During the winter season the maintenance items are increased in caring for ice removal and maintaining the heating and thawing facilities.

Track maintenance is materially affected in the track pan zone by the unusually wet conditions. Proper drainage facilities properly maintained reduce this item considerably, except probably during the winter and spring seasons.

Float valves on the pan connections must be inspected frequently and maintained in proper operating condition. A slight variation in the openings on shut off valves will result in wastage or improper operation.

Operation

In the climate through which we operate it is necessary to heat the water in the pans, and provide ice thawing facilities from November 1st to April 1st, inclusive. During the remainder of the year the majority of our installations are operated without any labor attendance. Exceptions cover

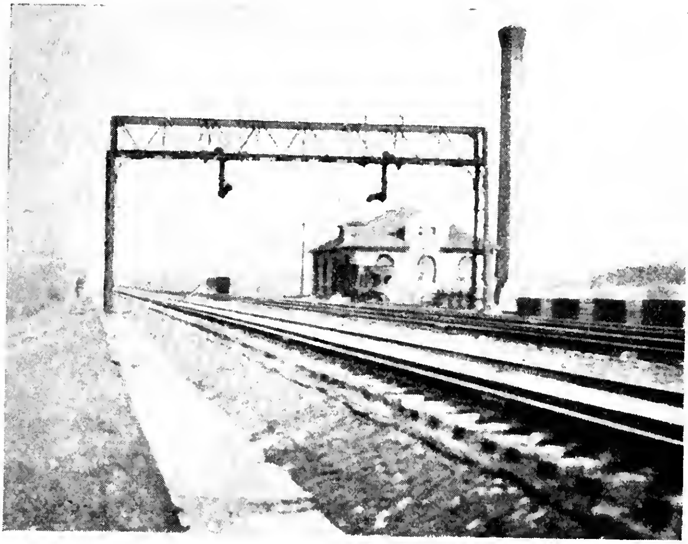


Fig. 1—Water Bridge, Track Pans and Pumping Station, Pennsylvania Railroad, Bark Mills, Del.

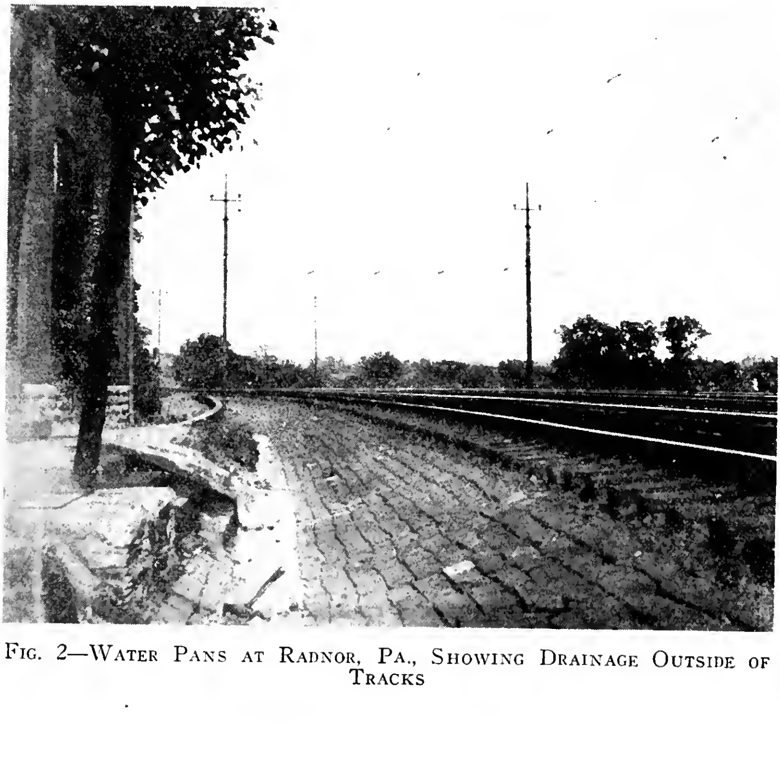


Fig. 2—Water Pans at Radnor, Pa., Showing Drainage Outside of Tracks

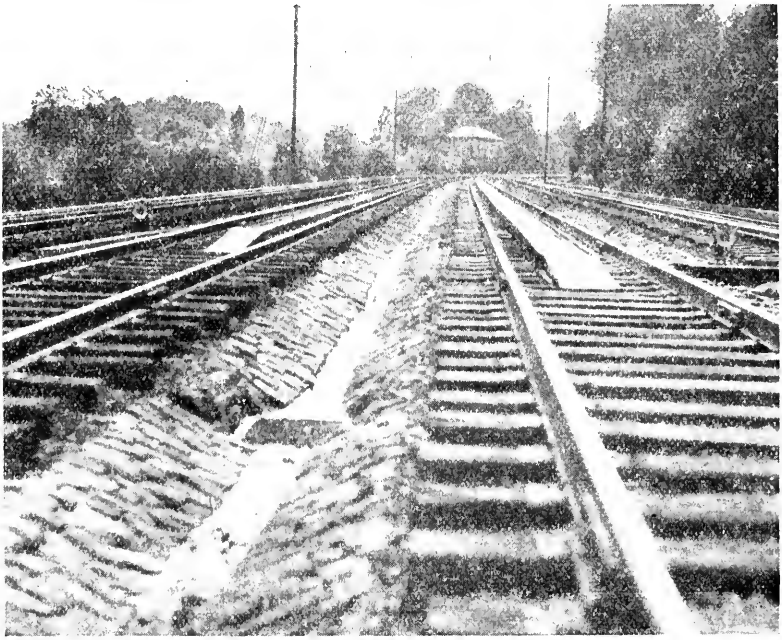


Fig. 3—Water Pans at Radnor, Pa., Showing Drainage Between Tracks

Fig. 4—Water Pans at Radnor, Pa., Four-Track System of Pans on Curve

the locations at which signal power equipment is maintained. At these stations a very small percentage of the operating expense is charged to the pans during the summer season.

The heating and thawing load varies throughout the winter with the varying temperature conditions. The heating and steaming boilers should, therefore, he laid out in a bank of average size boilers, so that the units can be taken off and put on the load at will.

The following cost figures cover track pan stations on our Pittsburgh Division, Central Region. The figures include operating expenses only. There is nothing included for maintenance and renewal of the pans, track, and power plant equipment. The winter season extends from November 1st to April 1st, inclusive. The summer season covers the balance of the year. At plans A and B the water is delivered by gravity and does not require treatment. At plant C the water is pumped from a river close by and the same requires chemical treatment.

		Plants	
General Description and Items	*A*	*B*	*C*
Number of pans, length and depth	2—1500x22x6 1—2600x22x6 1—2600x29x6	4—1800x29x6	2—1850x22x6 1—1800x22x6
Average daily water requirements—gallons	1,500,000	1,000,000	560,000
Operating Costs (Winter Season)			
Labor	$3,280	$3,205	$5,610
Coal	4,485	4,370	4,210
Chemicals	.....	.....	1,170
Oil, Waste and Packing, etc.	35	80	101
Operating Costs (Summer Season)			
Labor	868	889	6,118
Coal	455	770	1,869
Chemicals	.....	.....	2,730
Oil, Waste and Packing, etc.	7	7	67
Operating Expenses	$ 9,130	$ 9,321	$21,875
Purchase price of water, per year	50,000	47,450	......
Total Operating Cost	$59,130	$56,771	$21,875
With efficiency of 65 per cent, the water actually used per day equals	975,000	650,000	365,000
Cost per 1,000 gals. water used.	16.6 cts.	23.9 cts.	16.4 cts.
Carrying charge per 1,000 gals.		Various	

Appendix I

(10) METHODS USED IN OBTAINING SUCCESSFUL WELLS IN FINE SAND FORMATION

J. R. Hickox, Chairman, Sub-Committee; B. W. DeGeer, R. L. Holmes, F. H. Kornfeld, C. H. Koyl, H. H. Richardson.

The trouble experienced in getting an adequate railway water supply in fine sand is determined by the fineness of the sand. In formations where the sand is very fine, the amount of water that can be taken from one well is rather limited with any form of construction. Sands as fine as blow-sand that we have in the sand-dune country like northwestern Nebraska, for instance, will go through almost any opening.

Fortunately, in most places, by a little prospecting, a coarser vein can be found, from which the water can be taken; but where this cannot be done, it is necessary also taking into account the thickness of the water bearing stratum, to make the circumference of the circle, which represents the point of contact between fine sand and whatever is used to allow the water to pass and the sand not to pass, large enough, so that the flow will be slow enough to move the sand as little as possible.

One method used to accomplish this is to put down a very large casing; then, concentric with the casing, set the regular well casing and strainer and fill in between with sand which will not pass through the openings in the strainer, but which will have a very retarding effect upon the movement of the fine sand; then withdraw the outside casing to the top of the water-bearing stratum. Fig. No. 1 shows this method, also the method of holding the small casing and screen concentric with the larger one.

It is quite important to determine the capacity of a well in fine sand for any given draw-down. If the well is crowded beyond this capacity it will result in drawing sand into the well.

Where the depth to water-bearing sand is not too great, large dug wells can be made on this same principle and it has an advantage of storing the water in the well itself so that while pumping it can be withdrawn at a much higher rate and allow twenty-four hours for replenishing this supply. In cases where this cannot be done, after determining the capacity of one well, enough wells should be put down to give the desired quantity per hour, without causing excessive draw-down on any one well.

Fig. No. 2 illustrates another method that has proven quite successful. A large casing is put down to the bottom of the water-bearing stratum. A smaller casing and screen is then set inside and concentric with the large one. Both casings extend to the surface of the ground. The space between this is filled with coarse sand that will not pass through the strainer opening. Then the outer casing is raised slightly and the well pumped. This causes the fine sand to flow into the well and the coarse sand to flow down and take its place. The fine sand is removed from the well. The coarse sand

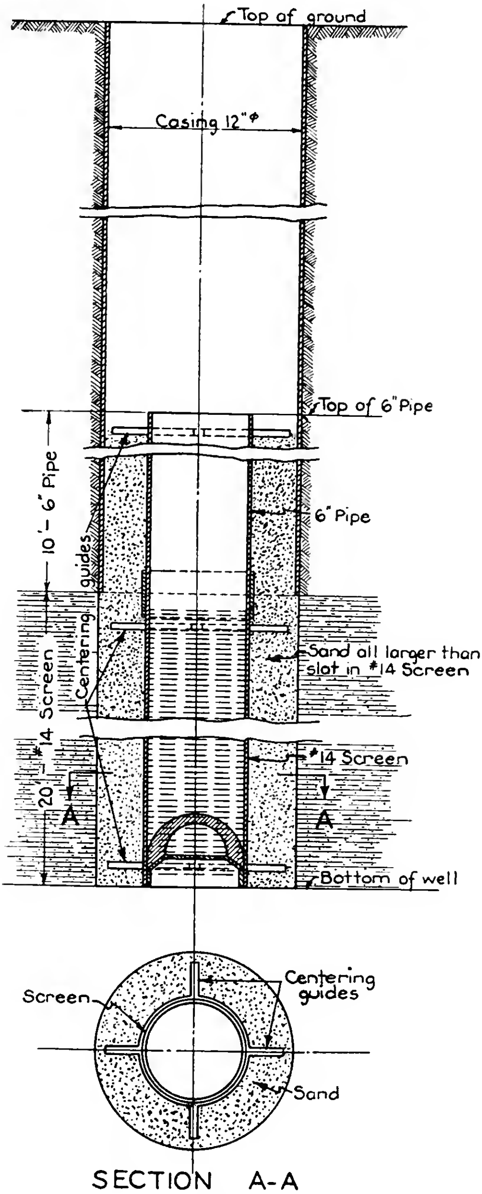


FIG. 1—METHOD OF SECURING WATER IN FINE SAND

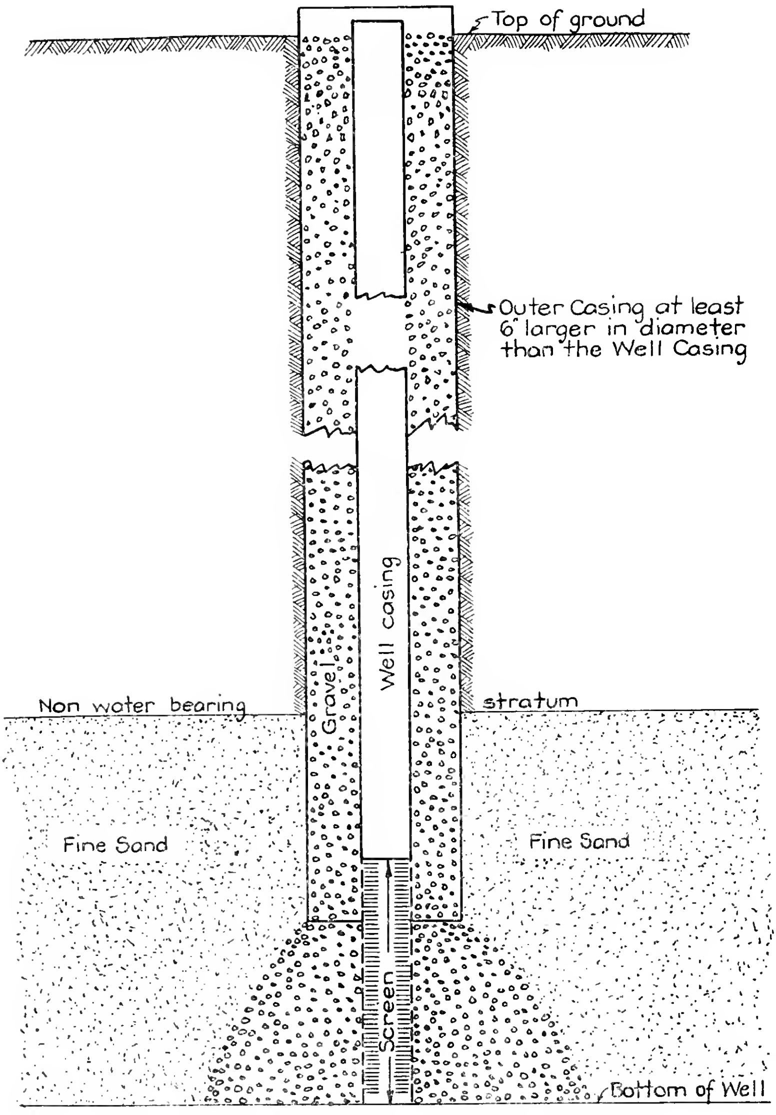


Fig. 2—Method of Securing Water in Fine Sand

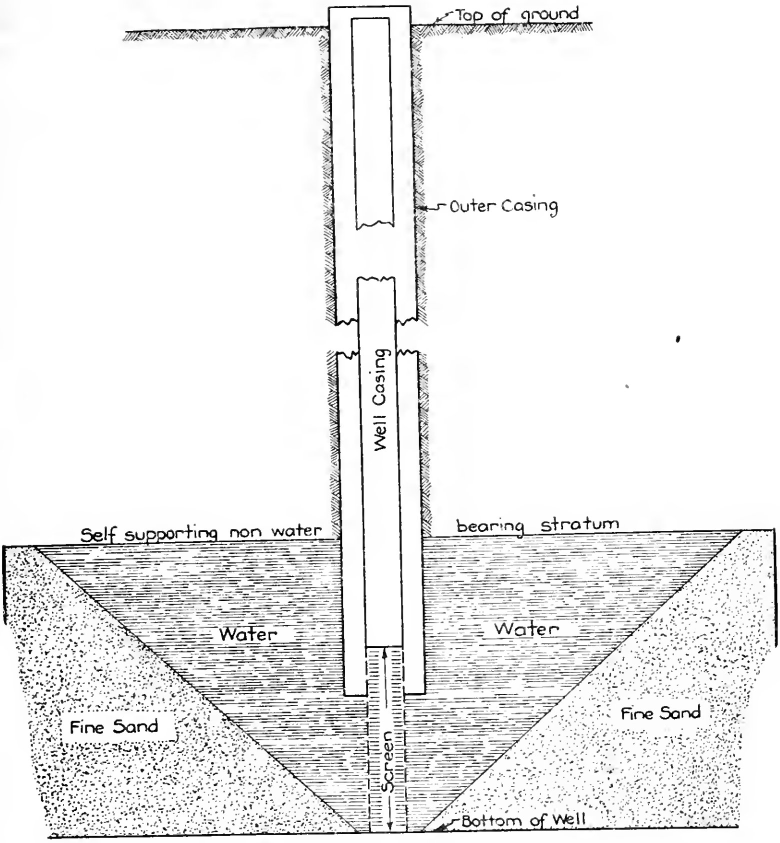


Fig. 3—Method of Securing Water in Fine Sand

between the casing is kept replenished. The outer casing is again raised and the process repeated until a sufficient quantity of coarse sand is deposited around the screen to enable the well to deliver the required amount of water or the capacity of the stratum.

It requires some time to develop a well of this kind and a very large coarse sand deposit can be made around the strainer in this way. One method of developing it is to use a turbine pump and first withdraw some water, then stop the pump and allow the water to flow back into the well, thus washing the water back and forth through the coarse sand and bringing the fine sand into the well casing where it can be removed.

Another method, provided the water raises to a considerable height in the well above the top of the water-bearing stratum, is to cap the inside casing and apply air pressure; depressing the column of water thus forcing water out of the well through the coarse sand. Then release the air pressure and allow it to flow back bringing some fine sand with it. The coarse sand goes down to take its place.

By repeating this process a sufficient number of times the well is developed to the required capacity. After putting the well into service the fine sand will often continue to come into the well and the coarse sand to flow down to take its place, but by replenishing the coarse sand a point is finally reached where conditions are stable.

Fig. No. 3 illustrates another method of developing a well. Where there is a strong enough impervious stratum overlying the sand, simply withdraw the sand, leaving a reservoir of water until the slope of the sand is flat enough so that it will not flow toward the screen.

This is rather an unusual condition, however, and cannot often be found practicable.

Appendix J

(11) STUDY AND REPORT ON WATER COLUMNS, THEIR ADVANTAGES OVER TANK DELIVERY, REQUIRED RANGE OF OPERATION, TYPE OF PIT, AND RELATIVE MERITS OF RIGID AND TELESCOPIC SPOUTS

J. P. Hanley, Chairman, Sub-Committee; B. W. DeGeer, F. H. Kornfeld, H. E. Silcox, R. A. Tanner, F. D. Yeaton.

GENERAL

The usual method of delivering water to locomotive tenders in the earlier periods of railway construction was through a spout directly connected to the roadside tank, the tank being used as a vessel for the storage of water as well as equipment for its delivery. Many of these installations still exist and the method continues to be generally satisfactory when used on branch lines or on main line divisions having a limited train movement.

On heavy traffic divisions and at locations where more than one track is served tank spout delivery has not been found generally adequate or suitable, and in such cases is being superseded by the use of water columns. In fact many railways now favor the elimination of the tank spout altogether, the location of the roadside tank at a considerable distance from the tracks for storage purposes only, and the delivery of all water to engine tenders through water columns.

Merits and Demerits of Water Columns and Tank Spouts

Water column installations 12 inches in size are common pratice, although it has been found difficult to operate tank outlet pipes of such diameter, consequently the increased size of the water column provides a faster and more convenient method of delivering water and saves time in train movement.

Water column use permits the roadside tank to be located at considerable distance from the tracks, thereby removing an obstruction from the view of engine and trainmen, and allowing space for future track development.

Water column use permits better spacing of tracks where two or more tracks are to be served.

Water column settings give a neater appearance around stations than tank spout settings.

Water columns can be moved with less expense than water tanks, and in case valve repairs are necessary can be shut off without emptying the tank which cannot be done with tank spout installations when the valve is to be repaired.

Water columns have the disadvantage of usually affording less side clearance than tanks; waste water in freezing weather on account of

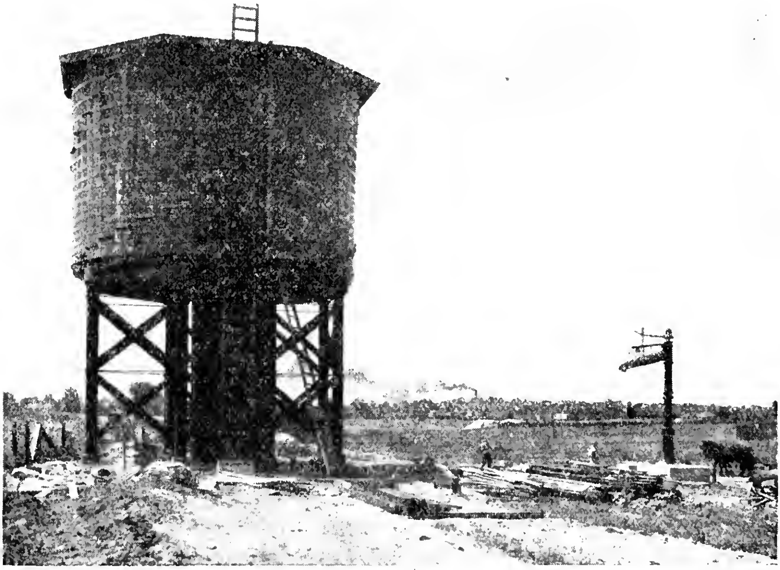


Fig. 1—Water Column, Illinois Central Railroad, Clinton, Ill.

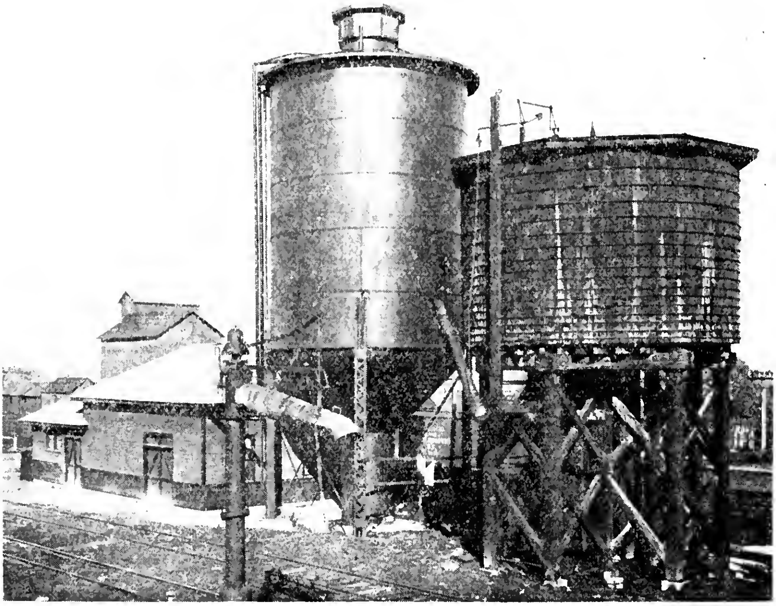


Fig. 2—Water Column, Illinois Central Railroad, Parkersburg, Iowa

column drainage after each filling operation, and cost more to install than tank spouts.

Range of Operation of Water Columns

Water columns are adapted to serve a wider range of track layouts than tank spouts. While it is common practice for railroads installing water columns to give same their "standard" side clearance, this clearance may be increased without impairing the service of the column. It might not be advisable from a safety clearance standpoint to decrease this clearance, but it may be increased considerably at locations where service is wanted by one column for two tracks.

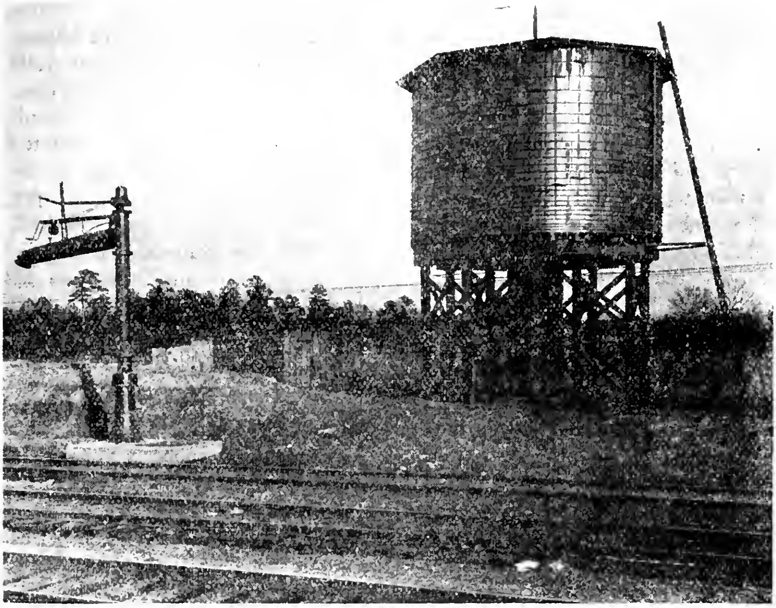


Fig. 3—Water Column with Tank Set Back from Track, Illinois Central System, Paxton, Ill.

The same degree of flexibility exists in fixing the height of the water column above the top of the track it serves, as the vertical clearance may be increased or decreased at reasonable cost to correspond with changes in the height or engine tenders which may occur after the column is installed.

Where two tracks are to be served one column may be used for each track, or the tracks may be spaced to proper clearance and one column set between them to serve both tracks. Where three or more tracks are to be served, a bridge may be used to support any or all of the column fixtures and when such a bridge is erected it is not necessary to provide "standard" side clearance as is usually done for a ground setting of the columns.

Type of Water Column Pit

Reinforced concrete is usually used for permanent water column pits; while timber such as second-hand bridge stringers and ties may be used for temporary installations. Pits should be of sufficient size to house the water column valve and permit easy access and clearance for workmen in making repairs. The depth of pits vary depending on climatic conditions, but should extend below the frost line in freezing sections. The column should be securely bolted to the pit by anchor bolts.

Concrete, while structurally strong, is not a good frost resister. Some forms of frostproofing usually benefit the operation of water columns enclosed by it in hard freezing locations. In northwestern Iowa the Illinois Central covers the outside of the pit top and the upper part of the pit walls with one thickness of 2-inch lumber, and covers the inside ceiling and upper section of walls with one thickness of 1 by 6 inch flooring. The pit drain is trapped to prevent the inflow of cold air by an elbow inserted in the end of the drain and turned downward into a small sump in the pit floor which holds a water seal over the end of it. The pits are extended below the frost line and obtain the benefit of a small amount of heat radiation given off by the earth at this point. The conservation of this heat by the methods mentioned benefits the water column operation by eliminating the penetration of frost through the bare concrete walls, and stops small freezing troubles in drain ports and valves.

Relative Merits of Rigid and Telescopic Spouts

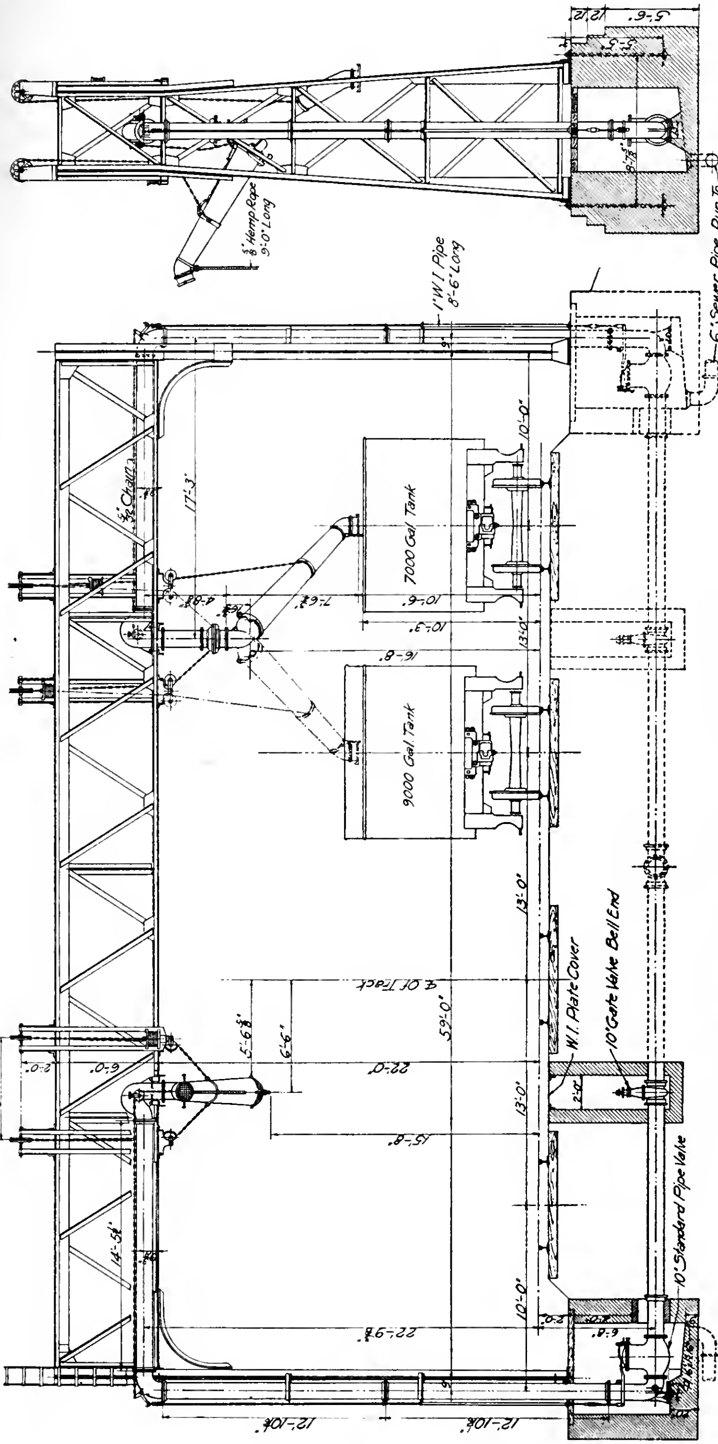
The earlier water columns were equipped with rigid spouts which permitted a radial movement only. This spout was succeeded by spouts with ball and socket joints and joints made of canvas and rubber composition, which gave trouble on account of leakage.

The telescopic spout was placed on the market in 1904 and has been improved until it is now a very satisfactory spout. The open joint at the point where the spout telescopes over the outlet elbow of the water column gives a wide range of adjustment both vertically and radially without joint leakage, and permits the insertion of the spout into the manhole opening of large and small engine tenders alike. This stops the splashing of water outside the manhole, which was rather prevalent when small tenders were filled with the rigid spout.

The telescopic spout decreases the liability of serious damage to the water column if the spout is struck by a moving car or engine as it is flexible enough to yield to the impact instead of bending or breaking. Under similar conditions, the telescopic spout operates with less loss of head and greater flow capacity than the rigid spout, and is more convenient to handle in filling engine tenders.

Delivery Capacity of Water Columns

Water columns usually operate under a low head, as a height of 20 feet from top of rail to bottom of tank has been standardized by many



—OVERHEAD WATERING SYSTEM FOR MULTIPLE TRACK LAYOUT—
—USED BY PENNSYLVANIA SYSTEM—

FIG. 4

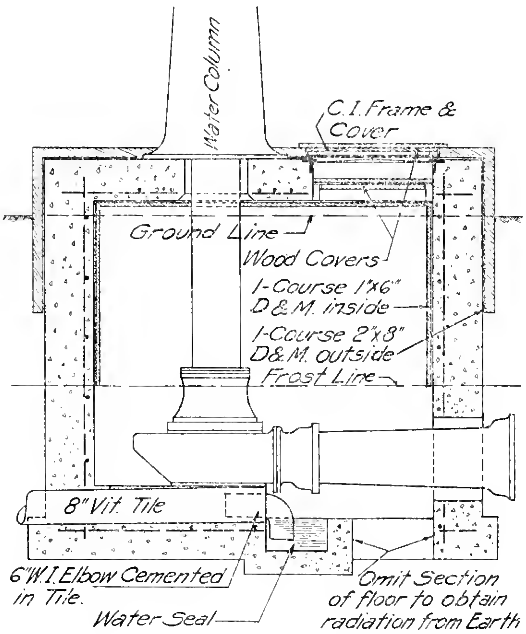


Fig. 5—Method of Frost Protection for Water Column Pits Used by Illinois Central Railroad in Northwestern Iowa

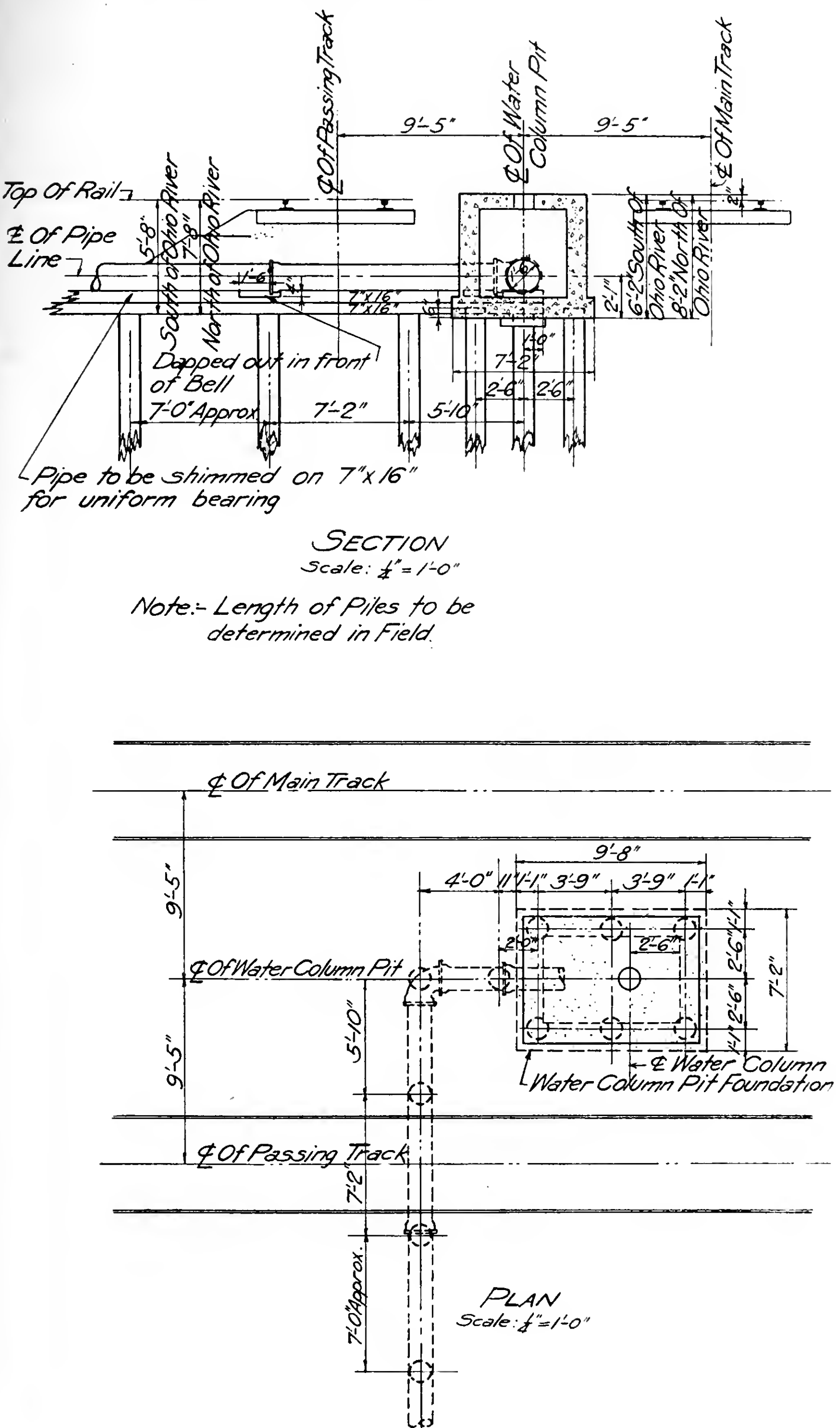


FIG. 6—PILING FOUNDATION USED BY ILLINOIS CENTRAL RAILROAD TO SUPPORT WATER COLUMN PITS IN NEW FILLS

A

railroads for water tank towers. On account of this low head it is often advisable to install the water column supply main one or two sizes larger than the water column it will serve. Cases of this kind would be where two or more columns are to be supplied by one main, or where one column is to be supplied by a main of unusual length. In the latter case an estimate should also be made to determine the relative economy of installing and operating an additional storage tank nearer the water column location, thus eliminating a part of the long supply main.

Your attention is directed to Bulletin No. 48 of the Engineering Experiment Station, University of Illinois, dated January 23, 1911, by Professors Talbot and Enger, entitled "Resistance to Flow Through Locomotive Water Columns," and reproduced in A.R.E.A. Proceedings, Vol. 11, Part 2, for 1910. This report shows in detail the tests made to determine the loss in head in fourteen types of commercial water columns under approximate service heads. The tests indicated that considerable difference in flow capacity exists between rigid and telescopic spouts and between the angle, globe and gate type of water column valves. It indicates the importance of selecting water columns designed on correct hydraulic as well as correct mechanical principles, in order to combine maximum flow with economy in installation and maintenance.

Conclusions

1. The water column is generally preferable to the tank spout on heavy traffic divisions or where more than one track is to be served. The tank spout is generally satisfactory for branch lines or light single track divisions.

2. Water columns are adaptable to a wide range of track layouts including single, double and multiple systems.

3. Reinforced concrete is best material for permanent water column pits. Pits should have good drainage and some form of frost proofing in hard freezing climates. Columns should be bolted directly to the pit by anchor bolts, flimsy blocking being avoided.

4. Telescopic spouts are easier to handle, waste less water and are generally preferable to rigid spouts.

5. Water columns should combine good hydraulic principles for large flow capacity with good mechanical principles for economy in installation and maintenance.

6. Water column mains should be of sufficient size to supply the maximum flow required through the column after deductions for friction losses in supply main and fittings between the column and the storage tank.

10" U.S. & MANSFIELD WATER COLUMN

DISCHARGE IN GALS PER MINUTE FROM 10" WATER COLUMN ON 10" MAIN

FLOW HEAD FEET	LENGTH OF MAIN IN FEET																
	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2500	3000
5	1350	1160	1030	930	850	790	740	705	670	640	590	540	510	480	460	410	380
10	1950	1650	1475	1340	1225	1150	1075	1030	970	910	840	790	740	700	660	590	540
15	2375	2050	1825	1650	1525	1420	1325	1250	1200	1150	1050	970	910	860	820	730	670
20	2750	2370	2125	1920	1760	1650	1550	1460	1390	1340	1210	1175	1075	1000	950	860	780
25	3090	2660	2370	2160	1980	1850	1740	1650	1570	1500	1370	1280	1200	1130	1075	970	890
30	3400	2910	2625	2375	2190	2040	1910	1810	1725	1650	1510	1410	1325	1250	1180	1060	980
40	3910	3400	3050	2760	2540	2375	2225	2110	2010	1910	1760	1640	1540	1460	1380	1240	1140
50	4400	3800	3420	3100	2950	2660	2500	2375	2260	2150	1975	1840	1730	1640	1550	1400	1230
60	4810	4280	3760	3410	3140	2940	2775	2610	2490	2375	2175	2030	1910	1800	1710	1540	1410
70	5210	4550	4090	3710	3400	3290	3000	2825	2700	2575	2360	2200	2075	1950	1850	1660	1530
80	5590	4850	4380	3980	3650	3410	3210	3040	2900	2775	2530	2360	2230	2100	2000	1790	1640
90	5920	5170	4650	4225	3890	3640	3410	3225	3100	2930	2700	2510	2375	2240	2125	1900	1750
100	6250	5450	4900	4450	4110	3840	3610	3410	3260	3110	2850	2660	2510	2350	2250	2010	1950

NOTE:—ABOVE FIGURES ARE BASED ON AVERAGE USED IRON PIPE AND SUBJECT TO VARIATION AS TO CONDITION OF SUPPLY MAINS

U.S. WIND ENGINE & PUMP CO., BATAVIA, ILL.

10" U.S. + MANSFIELD WATER COLUMN

DISCHARGE IN GALS. PER MINUTE FROM 10" WATER COLUMN ON 12" MAIN

FLOW HEAD FEET	LENGTH OF MAIN IN FEET																
	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2500	3000
5	1610	1460	1340	1250	1160	1100	1050	1000	950	910	850	800	750	720	680	620	560
10	2300	2090	1925	1790	1675	1590	1500	1440	1375	1325	1240	1160	1090	1040	990	900	820
15	2825	2575	2375	2210	2080	1960	1875	1780	1700	1650	1540	1440	1360	1290	1225	1110	1020
20	3280	3000	2775	2560	2420	2300	2180	2090	2000	1925	1800	1675	1580	1510	1440	1300	1200
25	3675	3350	3100	2900	2720	2580	2450	2350	2260	2175	2020	1900	1790	1700	1610	1460	1350
30	4040	3700	3410	3190	3000	2850	2700	2600	2490	2390	2230	2090	1975	1875	1790	1620	1480
40	4680	4290	3975	3700	3500	3310	3150	3020	2900	2780	2600	2440	2300	2200	2090	1890	1725
50	5250	4800	4450	4160	3900	3710	3550	3400	3260	3125	2930	2750	2600	2475	2350	2125	1950
60	5760	5290	4900	4580	4310	4100	3900	3750	3600	3450	3220	3025	2860	2720	2600	2350	2150
70	6225	5725	5300	4975	4675	4440	4240	4075	3900	3740	3500	3300	3110	2960	2810	2550	2325
80	6690	6125	5700	5325	5000	4775	4550	4375	4190	4010	3760	3530	3330	3175	3020	2740	2510
90	7100	6525	6050	5675	5320	5080	4850	4640	4460	4300	4010	3760	3560	3400	3220	2910	2675
100	7500	6900	6400	6000	5630	5350	5110	4900	4710	4520	4225	3975	3750	3580	3400	3080	2825

NOTE:—ABOVE FIGURES ARE BASED ON AVERAGE USED IRON PIPE AND SUBJECT TO VARIATION AS TO CONDITION OF SUPPLY MAINS.

U.S. WIND ENGINE + PUMP CO., BATAVIA, ILL.

10" U.S. & MANSFIELD WATER COLUMN

DISCHARGE IN GALS. PER MINUTE FROM 10" WATER COLUMN ON 14" MAIN

FLOW HEAD FEET	LENGTH OF MAIN IN FEET																
	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2500	3000
5	1760	1670	1590	1520	1450	1400	1350	1300	1260	1220	1150	1090	1050	1000	960	880	810
10	2510	2390	2275	2175	2080	2000	1940	1870	1810	1760	1660	1580	1500	1450	1380	1270	1175
15	3100	2950	2800	2690	2575	2475	2400	2310	2250	2175	2050	1960	1875	1800	1725	1575	1460
20	3600	3425	3260	3110	3000	2890	2790	2700	2610	2530	2400	2280	2180	2100	2010	1850	1710
25	4030	3830	3660	3500	3350	3240	3130	3030	2940	2850	2700	2575	2460	2350	2260	2080	1925
30	4425	4210	4030	3850	3700	3560	3450	3340	3230	3140	2980	2840	2710	2600	2500	2300	2120
40	5125	4900	4675	4475	4290	4140	4000	3875	3760	3660	3475	3300	3150	3040	2910	2675	2475
50	5750	5500	5240	5020	4825	4650	4500	4360	4240	4120	3900	3710	3550	3410	3280	3020	2800
60	6325	6020	5760	5530	5300	5120	4950	4800	4660	4525	4300	4100	3910	3760	3600	3325	3075
70	6840	6530	6250	6000	5750	5550	5375	5200	5050	4910	4675	4450	4250	4080	3910	3610	3340
80	7325	7000	6700	6425	6150	5950	5750	5575	5420	5280	5000	4775	4560	4400	4200	3880	3580
90	7800	7420	7130	6840	6550	6350	6125	5930	5800	5630	5350	5100	4850	4650	4475	4150	3820
100	8200	7870	7500	7200	6900	6700	6450	6250	6100	5930	5600	5375	5125	4900	4750	4375	4050

NOTE:— ABOVE FIGURES ARE BASED ON AVERAGE USED IRON PIPE AND SUBJECT TO VARIATION AS TO CONDITION OF SUPPLY MAINS.

U.S. WIND ENGINE & PUMP CO., BATAVIA, ILL.

12" U.S. & MANSFIELD WATER COLUMN

DISCHARGE IN GALS PER MINUTE FROM 12" WATER COLUMN ON 10" MAIN

FLOW HEAD FEET	LENGTH OF MAIN IN FEET																
	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2500	3000
5	1560	1280	1110	990	900	830	775	730	690	660	600	560	520	490	465	415	380
10	2210	1840	1600	1425	1300	1200	1120	1050	1000	950	870	800	750	710	675	600	550
15	2730	2270	1975	1760	1600	1480	1375	1300	1240	1175	1075	1000	930	880	830	740	675
20	3175	2650	2300	2050	1875	1740	1610	1520	1440	1370	1250	1160	1080	1025	970	870	790
25	3550	2960	2590	2310	2110	1950	1810	1710	1625	1540	1420	1310	1225	1150	1100	975	890
30	3900	3250	2850	2550	2325	2150	2000	1890	1790	1700	1560	1450	1350	1275	1210	1075	980
40	4525	3800	3300	2960	2700	2500	2330	2200	2075	1975	1825	1680	1575	1480	1400	1250	1150
50	5075	4250	3710	3375	3050	2810	2620	2475	2350	2275	2040	1900	1775	1675	1580	1420	1280
60	5560	4670	4100	3675	3350	3100	2875	2725	2575	2450	2250	2080	1950	1850	1750	1560	1420
70	6025	5075	4425	3975	3630	3360	3125	2950	2800	2660	2440	2260	2110	2000	1900	1700	1540
80	6450	5410	4750	4260	3900	3610	3360	3160	3000	2850	2625	2430	2275	2140	2040	1820	1650
90	6830	5775	5080	4550	4140	3840	3575	3375	3200	3040	2800	2590	2420	2290	2175	1940	1750
100	7250	6100	5350	4800	4390	4060	3780	3550	3375	3200	2950	2730	2550	2400	2300	2040	1850

NOTE:— ABOVE FIGURES ARE BASED ON AVERAGE USED IRON PIPE AND SUBJECT TO VARIATION AS TO CONDITION OF SUPPLY MAINS

U.S WIND ENGINE & PUMP CO., BATAVIA, ILL.

12" U.S. & MANSFIELD WATER COLUMN

DISCHARGE IN GALS. PER MINUTE FROM 12" WATER COLUMN ON 12" MAIN

FLOW HEAD FEET	LENGTH OF MAIN IN FEET																
	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2500	3000
5	2000	1730	1550	1410	1310	1215	1140	1080	1025	975	900	840	790	740	710	630	580
10	2860	2500	2225	2030	1880	1750	1650	1560	1480	1420	1300	1215	1140	1075	1025	920	840
15	3520	3075	2750	2500	2330	2175	2040	1940	1840	1760	1620	1510	1420	1340	1260	1150	1050
20	4100	3580	3210	2925	2710	2540	2390	2260	2150	2060	1900	1770	1660	1570	1490	1340	1225
25	4600	4010	3600	3300	3075	2850	2690	2550	2430	2325	2140	2000	1875	1760	1680	1510	1375
30	5050	4420	3975	3625	3375	3150	2950	2810	2675	2570	2360	2200	2060	1950	1860	1670	1525
40	5860	5125	4625	4225	3930	3680	3450	3280	3120	3000	2750	2570	2400	2275	2160	1940	1775
50	6580	5760	5200	4750	4410	4135	3890	3700	3510	3375	3100	2900	2720	2580	2440	2200	2010
60	7200	6350	5700	5230	4875	4550	4290	4075	3875	3720	3420	3200	3000	2830	2700	2410	2210
70	8390	7370	6650	6100	5675	5310	5000	4750	4520	4340	4000	3720	3500	3300	3130	2825	2590
80	8900	7850	7080	6500	6075	5675	5325	5060	4800	4620	4260	3975	3700	3525	3340	3010	2760
90	9400	8300	7500	6850	6400	6000	5620	5350	5090	4900	4500	4200	3920	3720	3530	3175	2910
100	7800	6875	6200	5690	5300	4950	4650	4425	4200	4040	3725	3460	3250	3080	3920	2630	2400

NOTE — ABOVE FIGURES ARE BASED ON AVERAGE USED IRON PIPE AND SUBJECT TO VARIATION AS TO CONDITION OF SUPPLY MAINS.

U.S. WIND ENGINE & PUMP CO., BATAVIA, ILL

12" U.S. & MANSFIELD WATER COLUMN
DISCHARGE IN GALS PER MINUTE FROM 12" WATER COLUMN ON 14" MAIN

FLOW HEAD FEET	LENGTH OF MAIN IN FEET																
	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2500	3000
5	2310	2110	1950	1825	1710	1625	1550	1475	1420	1360	1270	1190	1325	1070	1020	920	845
10	3310	3030	2810	2630	2480	2340	2230	2130	2050	1960	1840	1725	1680	1560	1480	1340	1225
15	4100	3750	3475	3250	3075	2910	2775	2650	2540	2450	2275	2150	2040	1940	1850	1670	1530
20	4750	4360	4040	3800	3575	3400	3240	3100	2975	2850	2660	2510	2370	2260	2160	1950	1790
25	5330	4900	4550	4270	4020	3820	3650	3490	3350	3210	3200	2830	2675	2550	2440	2200	2020
30	5875	5400	5000	4700	4430	4210	4020	3840	3690	3540	3315	3120	2950	2810	2690	2430	2230
40	6800	6260	5825	5460	5175	4900	4690	4475	4300	4130	3860	3640	3450	3290	3140	2840	2610
50	7640	7020	6550	6140	5825	5520	5275	5050	4850	4660	4350	4100	3880	3700	3540	3210	2940
60	8400	7725	7200	6775	6400	6080	5800	5575	5350	5140	4800	4525	4275	4090	3900	3550	3240
70	9100	8400	7800	7325	6950	6600	6300	6025	5800	5575	5200	4925	4650	4450	4250	3850	3525
80	9750	9000	8375	7875	7450	7075	6775	6475	6225	6000	5600	5300	5000	4775	4550	4125	3775
90	10400	9550	8900	8375	7950	7525	7200	6900	6625	6375	5950	5625	5325	5100	4850	4400	4025
100	11000	10200	9400	8850	8400	8000	7650	7300	7000	6750	6300	5950	5600	5400	5150	4650	4250

NOTE:—ABOVE FIGURES ARE BASED ON AVERAGE USED IRON PIPE AND SUBJECT TO VARIATION AS TO CONDITION OF SUPPLY MAINS

U S WIND ENGINE & PUMP CO., BATAVIA, ILL.

Appendix K

(11) PROGRESS BEING MADE BY FEDERAL AND STATE AUTHORITIES ON REGULATIONS PERTAINING TO DRINKING WATER SUPPLY

Dr. S. C. Beach, Chairman, Sub-Committee; R. C. Bardwell, W. L. Curtiss, A. B. Pierce, H. W. VanHovenberg.

The work of this Sub-Committee during the past year has been largely confined to keeping in touch with the investigations of the Joint Committee on Railway Sanitation, composed of representatives from the Medical and Surgical Section, the Mechanical Division, and the Engineering Division of the American Railway Association, and also the Public Health Service. On this Joint Committee, Dr. S. C. Beach, R. C. Bardwell and A. B. Pierce have been representing the American Railway Engineering Association.

This Joint Committee was originally appointed to study sanitary features pertaining to Drinking Water Supplies, but during the past year their duties were enlarged to include the scope of general sanitary practices covering type, facilities, and method of furnishing drinking water to passenger cars, and other allied features of railway sanitation, as well as quality of the supply.

Several meetings of the Joint Committee have been held during the past year and under date of March 31st, 1928, an extensive questionnaire was prepared and submitted to the Chief Operating Officers of all Class I railways to determine the best of present practices as well as obtain suggestions and ideas to assist in the preparation of any informatory pamphlet or Manual of recommended practices on matters affecting the handling of drinking or culinary water in coach yards and terminals, and other allied features of railway sanitation, in order to place this approved information before the railways of the country and avoid possible arbitrary rulings on these matters by Federal, State, or local health authorities.

The tabulation of replies to this questionnaire received from 78 railroads is being studied by the Joint Committee and it is expected that the information will be arranged in such shape that their recommendations can be submitted to this Association for consideration at time of next meeting.

Appendix L

(12) METHODS AND PRACTICES OF HANDLING WATER FOR DRINKING PURPOSES

W. B. McCaleb, Chairman, Sub-Committee; R. C. Bardwell, W. C. Curtiss, H. F. King, D. A. Steel, H. W. VanHovenberg, Dennistoun Wood.

Committee reports progress.

Appendix M

(13-A) METHODS OF PROVIDING DRINKING WATER AT COACH YARDS, INCLUDING STUDY OF HYDRANTS, NOZZLES, CONNECTIONS, ETC.

C. M. Bardwell, Chairman, Sub-Committee; R. L. Holmes, P. M. LaBach, W. B. McCaleb, A. B. Pierce, O. T. Rees, R. W. Savidge, H. W. Van Hovenberg.

The assignment of this Committee covers much of the same ground as last year's report in Appendix E, pages 158 to 171 of Vol. 29, Proceedings, "Types of Hydrants for Coach Yards and General Service and Methods of Supplying Water to Coaches." This Committee believes it desirable to present additional suggestions for the improvement of handling drinking water for passenger equipment which will diminish the likelihood of contamination of the water. It is difficult to overestimate the case with which pure water can be contaminated in transporting it from the hydrant to the storage tank in the passenger coach. The best of mechanical facilities are of no avail in preventing contamination of the water unless they are properly handled. The greatest opportunity for the improvement of the safeguarding of the drinking water supplied to passenger coaches is in the adequate instruction and supervision of the forces engaged in this work. The problem is one of supervision combined with the principles of sanitary control.

In the following discussion covering the use of hose, hydrants, nozzles and connections in watering passenger coaches, attention is directed to the details in handling which present the least opportunity for the contamination of the drinking water.

Hose

Hose for the delivery of water from the hydrants to the storage tanks on coaches, dining or other cars should be used for that sole purpose. Before use the hose should be thoroughly flushed out. When not in use the hose should not be permitted to lie upon the ground unless the nozzle is protected from contamination but should be stored in a special locker box or reel provided for that purpose. In moving the hose from one place to another the workmen should carry it by the ends so that the ends will not be permitted to drag upon the ground and thus be subjected to contamination.

Closest supervision is required to comply with the above recommendations, as it is very easy to mishandle the hose by dragging the nozzle upon the ground. It has been observed also that the drinking water hose is sometimes employed for other uses, as in washing out cars, toilets and other equipment whereby the hose is subject to contamination.

Nozzles

The hose should have a smooth nozzle in order to minimize the adherence of dirt. Special devices to protect the end of the nozzle are in use, such as caps and discs for the purpose of preventing the nozzle from touching the ground. Several of these were described on pages 170 to 173, Vol. 29 of the Proceedings. A print of the disc nozzle protector which is in common use is shown in Fig. 1.

Except that they apprize the handler that precautions in handling are necessary, nozzle protectors of various design have been noted to be of small value. Caps or nozzle protectors chained to the end of the hose intended for covering the end of the hose when it is not in use are frequently not utilized and sometimes accumulate dirt when dragged along the ground, which adds to the contamination of the nozzle. Disc nozzle protectors when dragged along the ground stir up much dust around the nozzle. One yard was observed to place wooden plugs in the end of the hose when not in use.

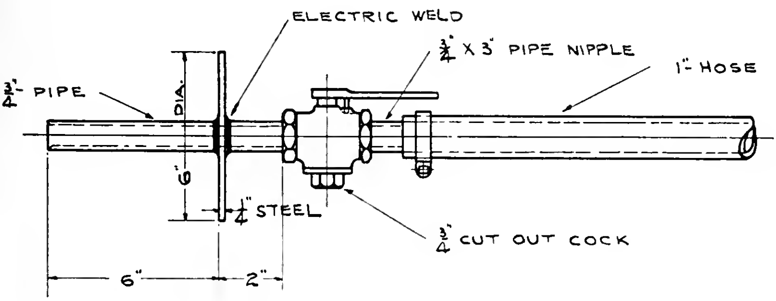


Fig. 1—Nozzle for Hose Used for Filling Water Tanks

When the hose was in use, however, these plugs were thrown on the ground where they were liable to contamination.

Buckets

Buckets having spouts and complete covers should be provided for the exclusive purpose of delivering water from the yard hydrant to the water coolers when delivery is made by this method. Buckets should be painted white and should be plainly marked "For Drinking Water Only." Special locker boxes should be provided for the sole storage of these buckets, and the buckets should be stored therein at all times except when in actual use. If it is desirable to have the water buckets conveniently available on the ice truck or cart, a separate protected compartment should be provided for the storage of the buckets in such a manner as to keep them entirely apart from the ice.

The opportunity presented for the contamination of drinking water supplied to passenger coaches where the water is handled in buckets warrants the close supervision of the employees engaged in this work. It may be more sanitary and less expensive to make alterations in such water coolers and to supply the coolers with safe bottled water.

Hydrants

Recommendations covering "Hydrants for Coach Yard and Passenger Station Platforms where Coaches Are Watered," pages 158 to 169, Vol. 29 of the Proceedings of this Association, are approved.

Hydrants should be located so as not to be subject to likelihood of contamination by toilet or other wastes discharged from passenger cars. Hydrants placed in pits or boxes flush with the surface of the ground should be properly safeguarded from contamination by leakage around the cover; should be well-drained and maintained in a sanitary manner.

Connections

Inlet connections on water storage tanks in passenger cars should be located so as not to be subject to the likelihood of contamination by toilet or other wastes discharged from the passenger car. Before attaching the nozzle of the hose to the inlet fixture all parts of the fixture which come in contact with the hose should be flushed off with a plentiful stream of certified water.

The design of inlet connections on passenger coaches sometimes makes it difficult to practice sanitary methods of supplying water. Most cars have connections for watering on one side only which makes it necessary for the workmen to crawl under the car and throw or drag the hose. Tapered filling connections to overhead tanks are located on some cars within two feet of the toilet hopper, so that when the wind is blowing or the car is in motion excreta from the toilet can blow over the drinking water connection. A member of this Committee washed several of these tapered connections with sterile water and ran analyses of the wash waters. In every case there was a positive test for B. Coli, indicating pollution. Fig. 2 illustrates this type of filling connection and shows its relation to the toilet hopper. Some roads have attempted to overcome this condition by enclosing the inlet connection in a metal box with an overhanging lid. (Fig. 2 and 3.) This method of protection has proven effective as long as the lid remains intact.

Personal Hygiene

Personal cleanliness on the part of employees engaged in the watering of cars should be rigidly required. Persons giving a history of having had typhoid fever should not be employed for such duties unless definitely proved not to be a carrier of that disease.

It has been observed that generally the cheapest available labor is employed in watering passenger equipment. For this reason it is essential that the men be given close supervision in regard to their personal hygiene as well as in the fulfillment of their duties.

The above recommendations are based on Circular M. and S. No. 76.

Inspection of coach yards and coach watering facilities over a wide section of the country by members of the Committee has shown that improvement can be made in the sanitary practice in the methods of supplying

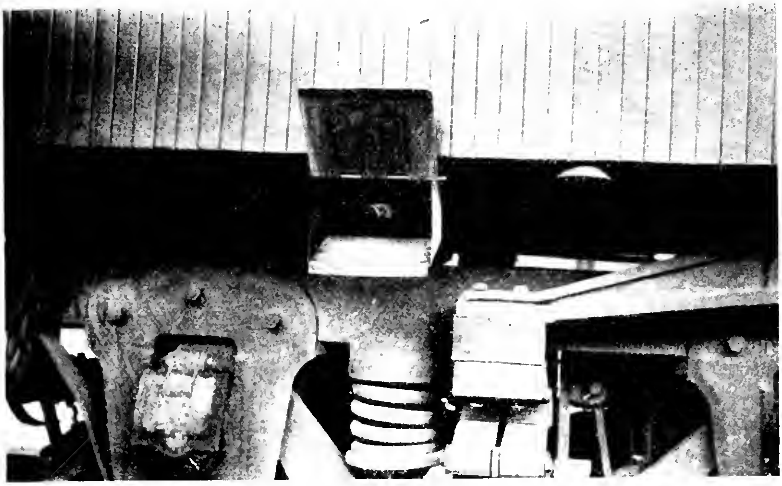


Fig. 2—Methods of Protecting Water Inlet of Coaches, Open

Fig. 3—Methods of Protecting Water Inlet of Coaches, Closed

drinking water to passenger coaches. Methods of handling drinking water at passenger stations where through trains are watered were also sometimes observed to be unsanitary. At these stations the men are under the handicap of having to work fast and were observed to sometimes drag the hose along the ground and throw it under the cars.

There is a distinct need of sanitary supervision on the railways with sufficient knowledge and authority to correct evil conditions. Coach yard employees cannot be expected to know the most sanitary methods or the importance thereof. It is essential that all foremen of men handling drinking water for passenger equipment be thoroughly informed as to the most sanitary methods of handling and that these foremen, in turn, instruct and supervise the workmen in their duty. The Committee believes that herein lies the greatest opportunity for improvement.

It is the opinion of the Committee that the present methods of handling drinking water from hydrant to car storage tank by means of hose sometimes leaves opportunity for contamination of the drinking water; that mechanical devices as nozzle protectors are of doubtful value.

Conclusions

1. Present methods of supplying drinking water to passenger coaches can be improved by more adequate supervision and instruction of forces watering coaches.

2. The methods and conditions of supplying water to passenger equipment should receive more interest and study so that a solution of the problem of avoiding all chances of contamination to drinking water supplied to passenger coaches might be found.

Appendix N

THE ASSOCIATION'S OPPORTUNITY FOR PROMOTING RAILWAY SANITATION

By H. W. Van Hovenberg

The railways of the United States are now required by law to comply with various rules and to maintain extensive equipment for the protection of the health of their patrons. Regulations of the Federal, state, county, and city governing bodies are becoming more stringent with the growth in this country of sentiment for preventive health work and the railways may expect to have railway sanitary regulations promulgated without co-ordination with good railway operating practices unless they, as a unit, are prepared to co-operate with the state and Federal bureaus of sanitation in formulating reasonable sanitary standards. This in itself warrants the attention the American Railway Engineering Association is giving to the matter of sanitary engineering as applied to railways.

Frequently, as the largest taxpayers in many cities and towns, the railways are called on to support local improvements, having for their object the better health and welfare of the citizens and requiring a large annual expenditure on the part of the railways. Happily, there is a growing sentiment on the part of the railways not to stand opposed to every local improvement of the kind described, but to take a real hand in the sane planning of such improvements, resulting in considerable economy, in more cordial mutual relations, and in better engineering practice.

If at this time any of the railways are lax in compliance with all of the sanitary codes of the states, there exists also a variance in these same code requirements as between states, and cities of states through which single railway systems operate. On the other hand, some of the railways are pioneering in the field of applied sanitation with very gratifying results.

The time is ripe for a better co-ordination of government sanitary requirements, based on practical railway operating conditions, and for a standardization of sanitary engineering practices by the railways as affecting operating and mechanical expenditures. We must expect that applied sanitation will cost something, but we should be convinced that our railways will be better off if these expenditures are practical and effective.

We may classify railway sanitation as follows:

(A) That required by national and state laws for the protection of patrons and community health.
(B) That which may be provided by the railways for the protection of health and for the comfort of employees.
(C) That which directly or indirectly has an important bearing on economical operation.

Many states have adopted the Standard Railway Sanitary Code as recommended for adoption May 25, 1920, by the Conference of State and Provincial Officers of Health. The portions of this Code governing the transportation of persons having communicable diseases provide for enforcement by the constituted health authorities. These provisions and those for the medical examination of food handlers are the only requirements of the Code affecting the medical profession. The other provisions of this Code which deal with the cleaning and disinfection of cars, cleaning of cars in service, sanitation of railway stations, and of construction camps, are purely matters of sanitary engineering in co-ordination with operating and mechanical practices and can be best handled by those having sanitary engineering training or proper instructions in this field of engineering. This embraces the handling of such items as drinking water in compliance with government standard requirements, heating and ventilation, scrubbing and cleaning, disinfection of cars, provisions for adequate toilet facilities, abatement of common drinking cups and towels, handling of refuse, proper screening, insect control, et cetera. The providing of appliances and personnel by Operating and Mechanical Officers for compliance with the Code is a mixture of engineering, sanitation and common-sense, but nowhere does it enter the realm of medicine and surgery, and there should be no confusion in the minds of railway officials in this respect. Neither should there be any confusion of this responsibility in the minds of railway Chief Surgeons or heads of Employees' Hospital Associations, as the line of demarkation between medicine and sanitary engineering on railways is clear-cut, with abundant opportunity for each specialty to work in its own province.

Many of our largest employers of labor have been reaping the benefits of applied sanitation for years, even among some corporations that offer only a small part of the opportunity for gain that may be found on railways. The field on railways covered by the words "railway sanitation" is too comprehensive to lead one to hope that any one railway will ever have the personnel competent to handle all phases of railway sanitation.

If we give a reasonable broad definition to railway sanitation, we may include such general or specialized work as, heating and ventilating; water supply engineering for all purposes; plumbing; sewage disposal; refuse disposal; disinfection of buildings, cars and cattle pens; standardization of disinfectants and cleaning supplies; insect and rodent control; sanitary regulations of dining cars, boarding cars, hotels and restaurants; sanitary maintenance of railway properties, including passenger cars, offices, station and railway structures; weed, grass and dust control; guidance to engineering parties with respect to protection of health by control of water, food and insects; sanitation of recreation camps, et cetera. Few of these items are covered by Federal or state regulations. The A.R.E.A. Manual is sorely deficient in information regarding any practices of the above items, as is evidenced in the case of sanitary advice in building construction to "avoid dark corners."

It is generally known that the cost of engineering for preliminary survey and location, and of contract bids were greatly increased in the construction of certain railways in the South due to malaria, a disease that is readily controllable. It is reputed that the engineering on one branch line, involving millions, ran about 10 per cent, compared with less than 5 per cent usually required, due to field parties being continually out of service with "chills and fever." A number of railways in the South have established malaria control as regular routine and with abundant return in each instance.

Who knows how much the railways are paying for deordorizing devices which often cover up poor cleaning when good sanitation would relegate them to the scrap-heap and substitute manpower and soap and water. Overheating and improper ventilation are undoubtedly the cause of much of our winter sickness affecting the well-being of thousands of employees who continue to work below par. Yet it is almost invariably the rule to find overheating of offices, with the consequent waste of fuel.

The necessity of providing safe drinking water for patrons and employees of railways is not debatable. Recent Supreme Court decisions give us abundant evidence of the course our courts will take in damage suits against corporations that are proved negligent in providing safe drinking water. The railways cannot afford to be complaisant in this connection when the present conditions are so obvious.

The Water Service Committee of the A.R.E.A. has recently been given authority to change its title to "Water Service and Sanitation." The majority of the members of the Committee have been handling as routine matters some problems of sanitation for their railways, so it is logical to charge this Committee with developing a comprehensive program and to expect that the committee membership will gradually include other representatives who have become proficient in the different phases of railway sanitation. Ultimately this Committee can, in close co-operation with state and Federal sanitary engineering bureaus, become a clearing house for standard railway sanitary engineering information, similar in function to other standing A.R.E.A. committees, and be in position to recommend standard practices with considerable economy or to advise in separate sanitary engineering problems of individual railroads. The membership of the A.R.E.A. is solicited to aid the Committee on Water Service and Sanitation, and to help to make it profitable and timely for our railways.

REPORT OF COMMITTEE I—ROADWAY

C. W. Baldridge, *Chairman;*
W. H. Woodbury, *Vice-Chairman;*
Anton Anderson,
H. B. Barry,
E. J. Bayer,
A. E. Botts,
W. G. Brown,
Paul Chipman,
A. C. Clark,
Hardy Cross,
G. S. Fanning,
J. L. Fergus,
J. A. Given,
J. S. Goodman,
F. W. Hillman,
Daniel Hillman,
A. A. Johnson,
Noah Johnson,
H. W. Legro,
H. T. Livingston,
L. C. Miller,
W. G. Morgan,
W. A. Murray,
W. M. Neptune,
J. A. Noble,
E. H. Olson,
E. C. Oyler,
O. V. Parsons,
T. M. Pittman, Jr.,
E. M. Smith,
W. C. Swartout,
H. E. Tyrrell,
Jamison Vawter,
Thomas Walker,
J. R. Wilks,

Committee.

To American Railway Engineering Association:

Your Committee respectfully presents herewith a report covering the following subjects:

1. Revision of Manual (Appendix A).

2. Continue the study of deformation of roadbed in the light of data developed by the Special Committee on Stresses in Railroad Track, with special reference to its effect on track maintenance (Appendix B).

3. Continue the study of improved methods for preventing corrosion of fence wire (Appendix C).

4. Continue the study of permanent roadbed construction, collaborating with Committee V—Track (Appendix D).

5. Develop and report upon the conditions which should govern the use of culverts in construction and maintenance, and the factors which determine the most suitable type to be used (Appendix E).

6. Develop and report upon drainage areas and water runoff, and the proper sizes of waterway openings required under the differing conditions in various parts of the country (Appendix F).

7. Prepare specifications for cast iron; for corrugated; and other types of metal culverts (Appendix G).

8. Develop best methods of preventing the formation of water pockets under the ballast when embankments are widened and/or raised (Appendix H).

9. Outline of work for ensuing year (Appendix I).

Bulletin 310, October, 1928.

Action Recommended

Subject No. 1.—Revision of Manual

The Committee offers the definitions given in Appendix A for inclusion in the Manual.

Subject No. 2.—Deformations in Roadbed

The report of the Committee is given in Appendix B and is offered as information, and it is recommended that the subject be discontinued.

Subject No. 3.—Corrosion of Fence Wire

The report of the Committee is given in Appendix C and is offered as information, and it is recommended that the subject be modified and reassigned.

Subject No. 4.—Permanent Roadbed

The report of the Committee is given in Appendix D and is offered as information. It is recommended that the subject be reassigned.

Subject No. 5.—Use of Culverts

The report of the Committee is given in Appendix E and is offered as information. It is recommended that the subject be discontinued.

Subject No. 6.—Drainage Areas and Water Runoff

The report of the Committee is given in Appendix F. The Committee reports progress and recommends that the subject be reassigned.

Subject No. 7.—Specifications for Culvert Pipe

The report of the Committee is given in Appendix G and is presented for a year's study by the Association, with expectation of offering the specifications at next year's Convention for inclusion in the Manual. It is recommended that the subject be reassigned.

Subject No. 8.—Prevention of the Creation of Water Pockets When Raising Grade

The report of the Committee is given in Appendix H, and it is recommended that the report be adopted for inclusion in the Manual, and that the subject be discontinued.

Subject No. 9.—Outline of Work for the Ensuing Year

The report of the Committee is given in Appendix I and is submitted for the consideration of the Executive Committee on Outline of Work.

Respectfully submitted,

THE COMMITTEE ON ROADWAY,

C. W. BALDRIDGE, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

W. H. Woodbury, Chairman, Sub-Committee; Anton Anderson, Paul Chipman, Daniel Hillman, W. G. Brown, A. A. Johnson.

The lack of a definition of the term "Grade" when used as a noun, has been called to the attention of the Committee, and to remedy that lack, the following definitions are offered:

Grade (noun).—The ratio of rise, or fall, of the grade line to its length, computed in length of construction stations.

Sub-Grade (noun).—The finished surface of the roadbed before the application of ballast or track.

Note.—The term "Grade" is sometimes used to designate the finished roadbed, but such use conflicts with the meaning of "Grade" as given above and it should not be so used.

The Committee has no other revisions of the Manual to offer this year.

Appendix B

(2) DEFORMATION OF ROADBED

Jamison Vawter, Chairman, Sub-Committee; H. B. Barry, Hardy Cross, J. L. Fergus, W. G. Morgan, T. M. Pittman, Jr.

In its last two reports (Vol. 28, A.R.E.A. Proceedings, page 849 and Vol. 29, page 543) the Committee gives its progress in the study of deformation of the roadbed. In these two reports and in Appendix D of the Roadway Committee Report of 1920, the work of the Special Committee on Stresses in Railroad Track with reference to pressures in ballast, is discussed. In the report of the Roadway Committee of last year, the questions considered as remedies in the matter of deformations were, drainage, deeper ballast and concrete slabs. Drainage has not been further considered beyond the recommendations contained in that report.

From a study of the Proceedings of the Association the Committee finds that the Ballast Committee and the Roadway Committee have in former years made a study of the questions of the proper depth of ballast to insure even pressure distribution and the use of concrete slabs.

Depth of Ballast

The most important references dealing with the proper depth of ballast are found in the following volumes of the A.R.E.A. Proceedings:

Vol. 7, 1906, pages 102-127. Discussion and translation of a lecture by Railroad Director Schubert given in Berlin in 1899 and covering experiments made in previous years. His conclusions were that the most favorable distribution of forces is accomplished by the use of broken stone ballast and recommended deeper ballast sections. The late Thos. H. Johnson of the Pennsylvania Railroad, from a study of the Schubert report, determined that the thickness of stone ballast required to produce an equal distribution of axle loads was 22⅔ inches, for a tie spacing of 23 inches.

Vol. 8, 1907, pages 52-59. A Study of the Stresses Existing in Track Superstructure and Rational Design Based Thereon, by O. E. Selby. Among other recommendations, he advises, for an axle load of 60,000 lb. and 20-inch tie spacing, 12 inches of stone upon 12 inches of gravel.

Vol. 13, 1912, pages 113-265. Copy of a report of a special committee appointed by the General Manager of the Pennsylvania Railroad. This work was done at Altoona, Pa., from 1908 to 1910, and report made March 15, 1911. The committee found that not less than 24 inches of ballast was required to distribute the load uniformly over the subgrade or roadbed. The committee recommended the use of 24 inches of stone ballast underneath the ties and in addition there should be provided a layer of engine cinder, gravel or an equivalent, to act as an absorbent mat to promptly and properly dispose of the water falling on the track, in such a manner to prevent its softening the roadbed material.

Vol. 13, 1912, pages 267-285. Translation of an article by C. Brauning on Gravel as Ballast. Recommends a depth of roadbed about 22 inches below the ties consisting of 12 inches of gravel and a layer of sand.

Vol. 14, 1913, page 145, and Vol. 16, 1915, page 1015. Proposed tests to determine proper depths of ballast.

Vol. 25, 1924, page 362. Appendix C of Roadway Committee report. The Effect of Heavier Power and Increased Tonnage Upon Roadbed Previously Stable. The sub-committee suggests the following remedies:

1. Strengthening the roadbed by better drainage (details omitted here).
2. Strengthening the roadbed by widening same (details omitted here).
3. Help the roadbed to function properly by a better distribution of the load.

This can be accomplished as follows:

(a) Increase the depth and quality of ballast.
(b) Increase the number of cross-ties per rail length.
(c) Increase the weight of rail.
(d) Pay more attention to the bolting and surfacing (tamping) of tracks.

Attention is also called to the recommendations of the Ballast Committee as given on page 79 of the 1921 Manual under "Proper Depth of Ballast."

From the foregoing it appears that all individuals or committees that have worked on the question of proper depth of ballast for uniform distribution of pressure have recommended a minimum depth somewhere in the neighborhood of the tie spacing, either all ballast material or rock ballast over some good sub-ballast. The same effect can also be accomplished by permitting the shallow ballast sections to penetrate the subgrade and keep bringing the track up to proper grade. This is usually the procedure followed which is one of the causes of the high early maintenance cost. Also care must be taken to avoid water pockets.

Sufficient data is not available on maintenance costs, as these are not segregated for various depths of ballast, to give an idea of the relative economy of initial installation of the recommended depth of ballast.

Use of Concrete Slabs

The following references deal with the question of concrete slabs under the track:

Vol. 20, 1919, pages 395-406. Concrete Eliminates Soft Spots in Railway Roadbeds, by J. T. Bowser. Recommends concrete slabs under ballast for soft pockets that are short in length and gives synopsis of correspondence and interviews with railroad officials regarding concrete slabs in railroad roadbeds.

Vol. 21, 1920, pages 447-465. Use of Reinforced Concrete Slabs to Assist the Ballast in Distributing the Load on Soft Roadbeds. Report of experience of various railroads.

Last year the Committee, on the basis of rough comparative costs it had, recommended that, in general, roadbed deformations .could best be eliminated by proper roadbed and proper depths of ballast but in certain bad spots the use of the slab might be a desirable remedy. It was stated that it would be necessary to have comparative maintenance costs for different ballast sections and various foundation conditions in order to make proper comparison of the above. The Committee has not been able to find these maintenance costs so segregated by any railroad where inquiry was made.

The 1924 I. C. C. Railroad Statistics indicate that the average cost of main track maintenance (Ballast and Track Laying and Surfacing) is around eight hundred dollars ($800) per mile per annum for Class A railroads. Figures indicate that on the better maintained heavy traffic lines the cost should be about 40 to 50 per cent greater. On that basis the Committee does not think the extensive use of slabs is justified except in yards or other places where a permanent form of track is desired and that the cost of installation in existing single track lines would be prohibitive.

Bearing Power of Soils

The Roadway Committee has made some studies in the past on the bearing power of soils but the information available deals mainly with foundations and not soil in the condition found in railroad embankments. Further study along that line might be justified.

Conclusions

In view of the foregoing the Committee believes that any further immediate study along the lines it has been following would be merely a repetition of work done before.

The Committee recommends that an effort be made to collect data relative to maintenance costs for various ballast depths and track conditions and that observations be made on recently constructed lines to determine the amount and rate of penetration of the ballast into the sub-grade during the period following construction.

For the present the Committee recommends that the subject be discontinued.

Appendix C

(3) PREVENTING CORROSION OF FENCE WIRE

E. J. Bayer, Chairman, Sub-Committee; H. E. Tyrrell, J. R. Wilks, W. A. Murray, E. H. Olson.

The Committee reports progress, but owing to the fact that other organizations have some tests of fence wire under way but not yet sufficiently completed to permit of results being determined, no report is offered this year.

Appendix D

(4) PERMANENT ROADBED

F. W. Hillman, Chairman, Sub-Committee; Paul Chipman, W. A. Murray, E. M. Smith, A. C. Clarke.

The subject assigned is "Continue the Study of Permanent Roadbed."

The Committee conferred with railroads it knew had some form of permanent roadbed and also made an inspection of the Pere Marquette Railway Company's installation at Beech, Michigan. Also, one member of the Committee inspected the roadbed in the Michigan Central Railroad's tunnel at Detroit, Michigan. Results are as follows:

Pere Marquette Railway Company's Track at Beech, Mich.

A description of this installation is given in 1927 A.R.E.A. Proceedings and a report on it is in 1928 Proceedings.

During August, 1928, the Committee made an inspection of this track. Two freight trains passed over it during the inspection, giving an opportunity to observe action of rails. There was some vertical motion of the south rail which has no insulating material under it, but very little vertical motion of the other rail which has insulating material between it and the concrete. Some of the bolts holding rail had broken and been replaced. Appearance of these indicated that it had been easily and successfully done. There is some spawling of concrete on top of slab at the joints, evidently caused by expansion crowding. While this is not serious, it suggests questions of how much space should be left between slabs for joints, how it should be filled and whether or not a tongue and groove joint is better than a vertical one. This spawling also suggests advisability of rounding of top edge of joints and providing more space at top of joint for a pliable filler. Following is a detailed report made by Mr. Chipman previous to Committee's inspection:

"The experimental section of concrete roadbed installed by the Pere Marquette at Beech, Michigan, in 1926, remains in essentially the same condition as a year ago. In January, 1928, the material formerly used for insulation under the rail having proven entirely unsuitable, it was removed and replaced with compressed wood fibre of the type ordinarily used for insulating switches. This material was applied for the entire length of the north rail. The south rail is in direct contact with the concrete. At the same time the gauge was reduced and the alinement improved by substituting rail clips which had a greater distance between the bolt hole and the shoulder that bears against the rail. The new insulation has eliminated signal trouble.

"Measurements of rail batter made in July show no increase since last December. In fact, these measurements show a decrease in the batter as defined by the A.R.E.A., but this is probably due to inaccuracy in measurement. The rails were not canted and after nineteen months' operation are not yet entirely covered by wheel wear, thus indicating that the rail wear is not excessive.

"No transverse cracks in the concrete developed since September, 1927, at which time a hair crack was discovered in slab No. 11 which extended the full width of the slab, in addition to the three slabs in which hair cracks had previously appeared. This makes four slabs out of a total of thirty-four in which such cracks extend for the full width of the slab. None of these cracks are wider than when first observed. No cutting of the rail into the concrete has yet occurred, at least not in a measurable amount.

"Since the rails were anchored on the approaches to the concrete roadbed, no creeping has been observed, except a forward and backward movement due to expansion and contraction. This movement does not exceed 2 inches at any point.

"Little change is noticeable in the riding qualities, although there appears to be a little less of the metallic clang which characterized the earlier operation. Perhaps this is due, at least in part, to the new insulation under the north rail and perhaps it is due to a general adjustment of contact surfaces. A similar improvement is found in rigid street car track construction after a few months' use.

"Additional settlement averaging about ½ inch took place between December, 1927, and July, 1928. This settlement took place during the winter and early spring, as indicated by some levels taken in April. These levels were taken on a very windy day, under such conditions that their accuracy is open to question. They have, therefore, not been made a matter of record, but they clearly show that this additional settlement had taken place at that time and that practically none has taken place since. This settlement, like that which preceded it, is so uniform that it does not affect the riding qualities of the track.

"The profile, Fig. 1, shows the settlement that has taken place from time to time. In the vertical scale, 1 inch equals 0.1 foot, or practically full scale; while the horizontal scale is 78 feet, or 2 slabs per inch. Levels of December 12, 1927, are not shown, as they were practically the same as those of August 25, 1927. From this profile it is apparent that slab No. 7 is on a hard spot and that slabs 22 and 23 are on a soft spot; that these conditions were developed in the first few days of operation; and that the relative settlement since that time has been quite uniform. Of the total settlement to date, the profile shows that about one-third developed in the first eleven days of operation, about one-third during the ensuing winter and early spring of 1927, and about one-third during the winter and early spring of 1928.

"Beginning with February 1, 1928, after the new insulation had been installed, a record was started of the labor and material used in maintaining the track on the concrete roadbed and a similar record for a section of the same length of ordinary track. This section is also located on the westbound main and is a short distance west of the concrete roadbed. This record has not been kept long enough to be of much value on either track, but is submitted for the months of February to July, inclusive, for what it is worth. The section of ordinary track has had little work done on it this season, but is about due for it now.

Concrete Roadbed, Pere Marpuette Railway

Settlement Under Traffic

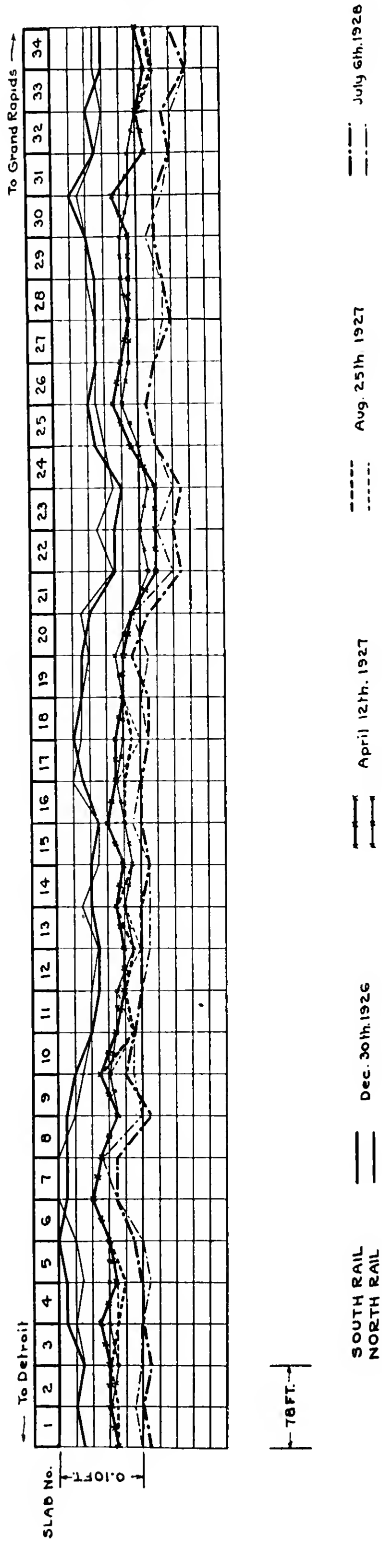


Fig. 1

One-Fourth Mile of Track on Concrete Roadbed

Month	*Item*	*Labor*		*Material*
Feb., 1928	....	Nil		Nil
March	Tightening clip bolts and replacing 4...	18 hrs. @ $0.45		
		6 hrs. @ .57	$11.52	4 bolts $0.13
April	Tightening clip bolts and replacing 4...	10 hrs. @ .45		4 bolts
		1 hr. @ .57	5.07	4 clips .50
May	Replacing 1 clip bolt	1 hr. @ .45	.45	1 bolt .05
June	....	Nil		Nil
July	Replacing 1 clip bolt	1 hr. @ .45	.45	1 bolt .05
	Total for 6 months................	....	$17.49	$0.73

One-Fourth Mile of Westbound Track

One Mile West of Beech

Month	*Item*	*Labor*	*Material*
Feb., 1928	Tightening bolts	$4.41	Nil
March	Tightening bolts	2.20	Nil
April	....	Nil	Nil
May	Surfacing	2.37	Nil
June	....	Nil	Nil
July	....	Nil	Nil
	Total for 6 months..............................	$8.98	

Michigan Central Railroad Tunnel, Detroit, Michigan

On page 349, Vol. 74, A.S.C.E., 1911 Proceedings, is a paper by W. S. Kinnear on construction of this tunnel. His description of the roadbed is given below and is followed by a report of an inspection made by one of our members on August 18, 1928:

"The track construction in the tunnel differs from the ordinary type in that the ties are not continuous from rail to rail. Each rail rests on ties 3 feet long; their outer ends are 19½ inches from the gage of the rail and the inner ends at the edge of the gutter. Every fifth tie on the right-hand side, in each tube, looking in the direction of traffic is extra long, to provide support for the third-rail. The ties rest directly on the concrete invert, which was built up to the grade of the bottoms of the ties. Each tie is laid on a bed of mortar $\frac{1}{16}$ inch thick for bonding purposes, and the ties are held in place by concrete placed between them to a depth of 5 inches at their outer ends, sloping toward the gutter to a thickness of 4 inches. Bond between this concrete and the invert proper is furnished by dowels.

"Before the tunnel was built, a short section of the Michigan Central Company's main-line track was changed to conform to the design proposed for the tunnel. This test section of track proved highly satisfactory, and the design was accordingly approved and adopted.

"The standard tie used in the tunnel is 8 by 11 inches and the rail is the 100-lb. A.S.C.E. section.

"The tunnel was opened for freight operation September 15, 1910. It is double track, with a tube for each track, but with the tubes integrally connected, with gutter in center of track. Trains are operated through the tunnel by electric locomotives, the third-rail system being used in the tunnel and approaches. At present the traffic amounts to about 1900 cars per day in each direction. This includes passenger equipment and trains in both directions.

"Ties.—Untreated yellow pine ties were used, both in the original construction and for renewals. Tie plates are used throughout. After 18 years' service, it is estimated that 70 per cent of the original ties are still in place. A large number of those taken out were damaged by derailments. Untreated pine ties were used instead of creosoted or oak ties, for the reason that they would absorb moisture and swell to such an extent that any motion of the tie would be prevented. This is regarded as an essential feature in the stability of the track. However, it makes the renewal of the ties a somewhat difficult and expensive matter, as they must be chopped out. Uniform conditions as to moisture have evidently had a very beneficial effect on the life of these ties. No figures are available as to the labor cost of tie renewals.

"Rail.—The 100-lb. rail originally laid was replaced by 105-lb. and later by 127-lb. open-hearth rail, except on one of the two 2-degree curves which are located near each end of the subaqueous portion of the tunnel. One of these curves is now laid with 105-lb. manganese rail on the high side and a special 93-lb. high carbon 'frictionless' rail with a narrow head on the other. These curves have a super-elevation of 2 inches. The open-hearth rail is renewed at intervals of four or five years, as compared, with 8 or 9 years outside the tunnel. This short life is not due to the track construction, as there is no more rail wear and no more batter than on ordinary track; but is due solely to corrosion of the base through electrolytic action. In order to reduce this, various kinds of paint have been tried; but so far without success. This action is somewhat less in the high carbon 'frictionless' rail and still less in the manganese. The latter has not been renewed, so no figures are available as to its ultimate life. Its renewal, however, will be occasioned by electrolysis, as the head is practically as good as new. The track is in good line and surface and very little labor is expended in keeping it so. Renewal with heavier rail entails considerable expense for adzing the ties and shimming up the pedestals which support the third-rail, in order to maintain the same vertical distance between the latter and the track rails.

"Conclusions.—Of the unusual items of expense involved in maintaining this track, only one, namely, the renewal of ties, is due to the type of track construction. The high expense of rail renewals is due to the causes mentioned above and to lack of room in which to assemble the material and do the work. The periodic cleaning of the tunnel is also an item of considerable expense, but this has no especial connection with the track construction. With the experience now acquired, better provision could be made for rail renewals and for cleaning. Probably electric current would be supplied overhead instead of by a third rail. None of these things, however, have any bearing on the utility of the track design, which seems to be very satisfactory for the purpose."

Chicago Junction Railway

This construction is described in Roadway Committee report in 1927 Proceedings. There was a total of 654 feet of track in this installation; 119 feet under one main track, 417 feet under second main track and 118 feet under a passing track. Cost, not including rail, was $1,830. It was laid in 1911 and gave very little trouble until 1921 when it was necessary to renew the ties which was very expensive. Subsequently, difficulty in holding track to good surface was encountered. Recently, a portion has been removed and replaced with standard construction, partly because of construction of a crossover, but also due to expense of maintenance. The tracks carry slow speed traffic of twelve to fifteen miles per hour and were not considered safe for higher speed when changes were made.

Delaware, Lackawanna & Western Railroad Bergen Hill Tunnel

The 1927 Proceedings, Vol. 28, page 864, contains a description of this installation. It was built in 1909 and replaced in 1925 with standard stone ballast construction. This because of failure of concrete and resulting difficulty in holding track to line and gage. Up to time of failure of concrete, maintenance cost on track was low. The rail did not last any longer than in standard track and occasionally developed battered joints.

Northern Pacific Railway Company

The installations on this railroad are described in 1927 Proceedings. Inquiries brought no further information than contained therein except to corroborate Mr. Tratman's remarks and subsequent comment by Mr. Baldridge.

Union Station, Chicago

This installation is described in Vol. 25 (page 104) of the Proceedings of this Association. During the past year there has been settlement of some of the slabs directly supporting rails, mud being forced up through some of the joints. Holes were drilled through the slab and air forced into them, thus forcing mud out. When water began to show clear, cement grout was forced under slabs with air until it began to show up through holes and joints. This was first done late in 1927 and appeared to be successful enough to warrant trying it more extensively. It must be remembered that conditions surrounding this installation are very unusual because bottom of slabs are a considerable distance below the surface of the Chicago River which is close by. However, the condition described above indicates that serious thought must be given to stability of foundation under slabs and possible necessity of varying design of slab as the bearing capacity of underlying soil differs.

In the Committee's 1927 report mention was made of the possibility of reduced train resistance with resulting discussion by Prof. Talbot. This year the Committee gave this phase of the matter some thought. It endeavored to learn of dynamometer car tests on track before and after being rebuilt with stiffer construction, but was unsuccessful. Thought was also given to making such tests on the Pere Marquette installation. Because of the comparatively short length, it does not seem that worthwhile results could be obtained in this manner. However, Mr. Chipman made some tests with drifting cars and his report on them follows:

"On July 9th, 1928, tests were made of the resistance of track laid on the Pere Marquette's experimental section of concrete roadbed at Beech, Michigan, and track of the usual type. These tests were made by measuring the retardation of drifting cars. The concrete roadbed is 1326 feet long and located on the westbound main track. Beginning at its west end four 300-foot sections were measured off, both on the westbound track and on the adjacent eastbound track, which is of ordinary construction.

"At the west end of each section an observer was stationed with a stop watch. The cars were kicked westward over the test section, first singly, then by twos, threes and fours. When the first wheel of the car or cut entered the first section, a signal was given at that point and the observers noted the time required to reach their respective stations. An initial speed was aimed at that would be sufficient to send all cars safely over the test section. The initial speed actually varied between nine and fifteen miles per hour. Except for unavoidable minor variations of speed, identically the same test was made on each track, and the same observers were at the same stations. The equipment used consisted of fifteen Pere Marquette steel hopper cars, ten loaded with company coal and five empty, together with a caboose.

In computing the resistance, it was assumed that it, and therefore the retardation, would be uniform throughout each 300-foot section. On this assumption the average velocity for each section was computed by dividing 300 by the time required to pass over the section. The loss in average velocity between two adjacent sections was then divided by the time in which this loss occurred, thus giving the retardation per second. On the assumption of uniform retardation throughout each section, the time at which the average velocity was attained would be the mean of the recorded times at the end of the section. The retardation per second, measured in feet per second, was then divided by 32.2, the acceleration of gravity, thus giving the total resistance in terms of the weight. The grade resistance was computed from levels taken on the tracks and was deducted from the total. In computing grade resistance, the approximate position of the center of gravity of each cut was used. The grade of both tracks was approximately 0.1 per cent, ascending westward, but on neither track was the grade exactly uniform, so that it was necessary to compute a different grade resistance for each track and for cuts of different lengths on each track.

"The three values thus obtained for each cut were averaged. Averages were also obtained from these figures for each group, that is single car cuts, two-car cuts, etc. These in turn were averaged, giving the same weight to each group, as each group consisted of the same cars; thus obtaining a grand average of 4.73 lb. per ton for the westbound track and 5.51 lb. per ton for the eastbound, a difference of 0.78 lb. per ton or 16 per cent.

"The resistance was also computed by comparing the velocity over the first section with that over the fourth or last section, with an average result of 4.38 lb. per ton for the westbound track and 5.24 lb. per ton for the eastbound, a difference of 0.86 lb. per ton, or 20 per cent. The advantage of the first method is that it utilizes all observations, whereas the second method eliminates those at Station 6. By the first method the results obtained by comparing the first and second sections, second and third sections, and third and fourth sections, are subject to a considerable variation due to errors of observation and the personal equation of the observers. These irregularities are to a large extent eliminated by averaging the three computations.

"For most of the cuts, time was taken at all stations; but in a few instances, one or more of the observers failed to get the time. Under the first method of computation, if a comparison between any two adjacent sections were possible, it was made and used in getting the average resistance for that particular cut, even though comparison of the remaining sections could not be made. For example, if there were readings at the end of the first and second sections, but none at the end of the third, it would only be possible to determine the resistance by a comparison of the velocity over the first and second sections, and this result would be used for that cut of cars. Under the second method no cut could be used for which readings at the end of the first third and fourth sections were not available. In other words, there were a few cuts available for the computation by the first method, that were not available by the second method. The majority of these cuts were empty cars, with a much higher resistance than the loads. This accounts for the higher average resistance for both tracks obtained by the first method, but it will be noted that the difference in resistance is not greatly affected. If the cuts not available for use by the second method be eliminated from the computation by the first method, the results are not far different than those arrived at by the second method, the final average for the westbound track being 4.52 lb. per ton, while that of the eastbound is 5.39 lb.

per ton. In no case, by either method, was any cut included, unless there was sufficient data to permit computation of the resistance for both tracks, that is to say, if readings on the westbound track were lacking to such an extent that the resistance could not be computated for any section, the readings for this cut on the other track were not used.

"The weather during the experiment was mostly fair, except for a hard shower, during which the work was suspended. The temperature was between 75 and 80 degrees. There was very little wind, except during the first part of the shower and a few moments preceding it. Such breeze as was blowing was from the south and almost at right angles to the movement of the cars.

"The eastbound track is laid with 90-lb. rail, rolled in 1923, in good condition with very little batter, with treated hardwood ties on about 12 inches of gravel ballast. The westbound track is laid with 90-lb. rail, rolled in 1926. One rail rests directly on the concrete base, but for the purpose of insulation the other rail is separated from the concrete base by a layer of very hard wood fibre, about 1/8 of an inch thick.

"The methods used in this test were rather crude, and more extensive and more accurate tests might show either more or less difference in the resistance of the two types of track. The results of this test cannot therefore be considered an accurate measure of such difference, but they do plainly indicate that there is a very substantial difference in favor of a rigid roadbed.

"The calculations for these tests are shown in Tables 1 and 2. These calculations were submitted to Professor Talbot for criticism. His reply, together with letter from Professor E. C. Schmidt and a statement from Professor E. G. Young, follows. The plats referred to by Professor Young are not presented because of lack of time to prepare them for reproduction in the Bulletin. While they represent a lot of detailed work on the part of Professor Young, it is thought that omitting them will not detract from his valuable comment and conclusion. Neither are the six original calculations referred to indicated."

Dear Mr. Chipman:

"I am enclosing herewith the computation sheets on data on resistance tests accompanying your letter of August 13. I am also sending you the letter of Professor E. C. Schmidt of October 1 which reviews the methods of tests and calculations and gives impressions of the report as well as some suggestions, together with Professor E. G. Young's memorandum on the tests and four plots of results. It is evident that Professor Schmidt and Professor Young have given this careful consideration, and I think their experience in such tests warrants reliance being placed on their study and conclusions.

"Your judgment on the review of the tests and the results will be much better than any opinion I can offer, so I will refrain from comment except to say that the plot of results which omits sets of timing and separates empty and loaded cars seems much more convincing that the plots having such scattered values, and particularly having so many low values.

"I am glad that Professor Schmidt and Professor Young have been willing to make so thorough a study of the results. If you have any question to raise with them or any further information to offer, I feel sure that they are sufficiently interested in the matter to be glad to give more time to it.

Very truly yours,

(Signed) A. N. TALBOT."

PERE MARQUETTE

Comparative test of resistance of cars on westbound

Test section on each track 1200 feet in length, Station 628 - 00

Westbound track, 90-lb. rail

Eastbound track 90-lb. rail, 1923, hardwood ties

TABLE 1 COMPUTATION OF RESISTANCE BY

Car No.	Load or Empty	Track	Time in seconds from Sta. 0 to Sta. 3	Sta. 6	Sta. 9	Sta. 12	Average Velocity Sta. 0-3	Sta. 3-6	Retardation (8) Minus (9)	Time (5)/2	Per Sec. 10/11	Resistance Total (12)/32.2	Grade	Other	Average Velocity Sta. 3-6	Sta. 6-9
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Single Car Cuts														
14204	E	W-bd.	13.4	28.6	46.4	70.0	22.39	19.74	2.65	14.3	.1853	.00575	.00093	.00482	19.74	16.85
"	E	E-bd.	15.6	34.4	61.4	112.8	19.23	15.96	3.27	17.2	.1901	.00590	.00110	.00480	15.96	11.11
15081	E	W-bd.	13.6	29.4	46.8	69.0	21.74	19.23	2.51	14.7	.1707	.00530	.00093	00437	19.23	17.24
"	E	E-bd.	15.6	34.4	60.4	94.4	19.23	15.96	3.27	17.2	1901	.00590	.00110	.00480	15.96	11.54
14324	E	W-bd.	13.2	29.0	47.4	69.8	22.73	18.99	3.74	14.5	.2579	.00801	.00093	.00708	18.99	16.30
"	E	E-bd.	18.4	37.0	68.6	-	18.29	14.56	3.73	18.5	.2016	.00626	.00110	.00518	14.56	9.49
13064	E	W-bd	13.8	29.6	48.4	73.4	21.74	18.99	2.75	14.8	.1858	.00577	.00093	.00484	18.99	15.96
"	E	E-bd.	14.4	31.0	52.0	-	20.83	18.07	2.76	15.5	.1781	.00553	.00110	.00443	18.07	14.29
13953	E	W-bd.	15.2	33.4	56.8	98.4	19.74	16.48	3.26	16.7	1952	.00606	.00093	.00513	16.48	12.82
"	E	E-bd.	12.8	27.2	46.6	69.8	23.44	20.83	2.61	13.6	.1919	.00596	.00110	.00486	20.83	16.30
13096	L	W-bd.	-	38.0	60.4	88.4	-	-	-	19.0	-	-	-	-	-	13.39
"	L	E-bd	13.4	27.6	43.0	60.8	22.39	21.13	1.26	13.8	.0913	.00284	.00110	00174	21.13	19.48
14273	L	W-bd.	15.8	33.0	51.2	73.6	18.99	17.44	1.55	16.5	.0939	.00292	.00093	.00199	17.44	16.48
"	L	E-bd.	-	29.0	44.6	62.2	-	-	-	14.5		-	-	-		19.23
15040	L	W-bd.	16.6	33.8	52.0	73.2	18.07	17.44	0.63	16.9	.0373	.00116	.00093	.00023	17.44	16.48
"	L	E-bd.	13.2	27.4	42.8	60.0	22.73	21.13	1.60	13.7	.1168	.00363	.00110	.00253	21.13	19.48
13409	L	W-bd.	16.0	32.6	51.0	72.4	18.75	18.07	0.68	16.3	.0417	.00130	.00093	.00037	18.07	16.30
"	L	E-bd.	15.0	31.4	49.0	69.8	20.00	18.29	1.71	15.7	.1089	.00336	.00110	.00228	18.29	17.06
14262	L	W-bd.	16.6	33.0	52.0	74.0	19.23	17.24	1.99	16.5	.1206	.00375	.00093	.00282	17.24	15.79
"	L	E-bd.	15.0	31.4	49.2	70.4	20.00	18.29	1.71	15.7	.1089	00338	.00110	.00228	18.29	16.85
15047	L	W-bd.	14.8	30.2	47.8	67.6	20.27	19.48	0.79	15.1	.0523	.00162	.00093	.00069	19.48	17.06
"	L	E-bd.	16.6	35.0	55.4	80.6	18.07	16.30	1.77	17.5	.1011	.00314	.00110	.00204	16.30	14.71
15025	L	W-bd.	16.4	32.0	49.4	68.6	19.48	18.07	1.41	16.0	.0881	.00274	.00093	.00181	18.07	17.24
"	L	E-bd.	16.4	33.0	52.0	72.8	19.48	17.05	2.43	16.5	.1473	.00457	.00110	.00347	17.05	15.79
		Two Car Cuts														
Caboose		W-bd.)	14.4	30.8	49.2	73.0	20.83	18.53	2.31	15.3	.1510	.00469	.00093	.00376	18.52	16.13
14204	E	E-bd.)	-	29.0	47.2	71.8	-	-	-	14.5	-	-	-	-	-	16.48
15081	E	W-bd (	13.4	28.6	45.8	65.8	22.39	19.74	2.65	14.3	.1853	.00575	.00093	.00482	19.74	17.44
14324	E	E-bd. (	13.6	29.4	48.2	72.6	22.06	16.99	3.07	14.7	.2068	.00648	.00090	.00558	18.99	15.96
13064	E	W-bd.)	15.2	33.4	56.0	88.8	19.74	16.48	3.26	16.7	.1952	.00606	00093	.00513	16.48	13.27
13953	E	E-bd.)	13.4	26.4	46.4	68.8	22.39	20.00	2.39	14.2	.1683	.00523	.00090	.00433	20.00	16.67
13906	L	W-bd. (	16.0	34.2	54.8	77.8	18.75	16.48	2.27	17.1	.1327	.00412	.00093	.00319	16.48	14.56
14273	L	E-bd. (	15.6	32.4	60.4	72.0	19.23	17.86	1.37	16.2	.0846	.00263	.00090	.00173	17.86	16.67
15040	L	W-bd)	16.2	34.6	54.8	77.4	18.52	16.13	2.39	17.4	.1374	.00427	.00093	.00334	16.13	15.00
13409	L	E-bd.)	15.6	32.6	51.2	71.6	19.23	17.65	1.58	16.3	.0969	.00301	.00090	.00211	17.65	18.13
13873	L	W-bd. (	20.2	43.2	70.0	104.2	14.85	13.04	1.81	21.6	.0838	.00260	.00093	.00167	13.04	11.19
14262	L	E-bd. (	17.4	37.0	58.2	84.8	17.24	15.31	1.93	18.5	.1043	.00324	.00090	.00234	15.31	14.15
15047	L	W-bd.)	17.0	35.6	55.6	78.4	17.65	16.13	1.52	17.8	.0854	.00265	.00093	.00172	16.13	15.00
14197	L	E-bd.)	17.0	36.0	57.6	82.6	17.65	15.79	1.86	18.0	.1033	.00321	.00090	.00231	15.79	13.76
15025	L	W-bd. (	16.2	31.8	50.2	70.2	19.74	18.07	1.67	15.9	.1050	.00326	.00093	.00233	18.07	16.30
13084	L	E-bd. (	16.0	33.4	52.0	74.2	18.75	17.24	1.51	16.7	.0904	.00281	.00090	.00191	17.24	16.13
		Three Car Cuts														
14204	E	)														
15081	E	W-bd.)	17.2	38.0	66.4	102.2	17.44	14.42	3.02	19.0	.1589	.00493	.00093	.00400	14.42	10.56
14324	E	E-bd.)	14.0	30.0	48.4	72.4	21.43	18.75	2.68	15.0	.1787	.00555	.00070	.00485	18.75	16.30
13064	E	(														
13953	E	W-bd. (	17.0	37.0	61.0	87.6	17.65	15.00	2.65	18.5	.1432	.00445	.00093	.00352	15.00	12.50
13906	L	E-bd. (	14.6	31.6	50.8	74.8	20.55	17.65	2.90	15.8	.1836	.00570	.00070	.00500	17.65	15.63
14273	L	)														
15040	L	W-bd.)	19.8	42.0	68.0	97.8	15.15	13.51	1.64	21.0	.0761	.00243	.00093	.00150	13.51	11.54
13409	L	E-bd.)	15.0	31.4	48.8	67.4	20.00	18.29	1.71	15.7	.1089	.00338	.00070	.00268	18.29	17.24
13873	L	(														
14262	L	W-bd. (	19.0	40.0	64.8	92.4	15.79	14.29	1.50	20.0	.0750	.00233	.00093	.00140	14.29	12.10
15047	L	E-bd. (	17.4	37.4	60.4	90.8	17.24	15.00	2.24	18.7	.1198	.00372	.00070	.00302	15.00	13.04
14197		)														
15025	L	W-bd.)	17.0	36.4	58.2	82.0	17.65	15.46	2.19	18.2	.1203	.00374	.00093	.00281	15.46	13.76
13084	L	E-bd.)	17.2	35.8	55.6	79.6	17.44	16.13	1.31	17.9	.0732	.00227	.0070	.00157	16.13	15.15

RAIL'AY COMPANY
and eastbound main tracks at Beech, Mich., July 9, 1926.
(equals Station 0 of test) to Station 640 - 00 (equals Station 12 of test)
1926, on concrete roadbed.
on approximately 12 inches of gravel ballast.

COMPARISON OF VELOCITIES ON ADJACENT SECTIONS

Retardation: (16) minus (17)	Retardation: Time $\frac{6-4}{2}$	Retardation: Per Sec. $\frac{18}{19}$	Resistance: Total $\frac{(20)}{32.2}$	Resistance: Grade	Resistance: Other	Average Velocity: Sta. 6-9	Average Velocity: Sta. 9-12	Retardation: (24) minus (25)	Retardation: Time $\frac{(7-5)}{2}$	Retardation: Per Sec. $\frac{(26)}{(27)}$	Resistance: Total $\frac{(28)}{32.2}$	Resistance: Grade	Resistance: Other	Ave. Resistance except grade $\frac{(15)+(23)+(31)}{3}$
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
2.89	16.5	.1751	.00544	.00093	.00451	16.85	12.71	4.14	20.7	.200	.00621	.00113	.00506	.004803
4.65	22.9	.2118	.00658	.00123	.00535	11.11	5.84	5.27	39.2	.1344	.00417	.00147	00270	.004283
1.99	16.5	.1206	.00375	.00093	.00282	17.24	13.51	3.73	19.8	.1884	.00585	.00113	.00472	.003970
4.42	22.4	.1973	.00613	.00123	00490	11.64	8.82	2.72	30.0	.0907	.00282	.00147	.00136	.003683
2.69	17.1	.1673	.00489	.00093	.00396	16.30	13.39	2.91	20.4	.1426	.00443	.00113	.00330	.00478
5.07	26.1	.1943	.00603	00123	.00480	9.49	-	-	-	-	-	-	-	.00498
3.03	17.3	.1751	.00544	.00093	.00451	15.96	12.00	3.96	21.9	.1806	.00561	.00113	.00448	.004610
3.78	18.6	.2011	.00625	.00123	.00492	14.29	-	-	-	-	-	-	-	.004675
3.56	20.8	.1760	.00547	.00093	.00454	12.82	7.21	5.61	32.5	.1726	.00536	.00113	.00423	.004833
4.53	16 4	.2762	.00658	00123	.00735	16.30	12.40	3.90	21.3	.1831	.00569	.00147	.00422	.005477
-	-	-	-	-	-	13.39	10.71	2.68	25.2	.1064	.00330	.00113	.00217	.00217
1.65	14.8	1116	.00348	.00123	00223	19.48	16.85	2.63	16.8	.1584	.00492	.00147	.00346	.002473
0 96	17.7	.0542	.00168	.00093	.00075	16.48	13.39	3.09	20.3	.1522	.00473	.00113	.00360	.002118
	-	-	-	-	-	19.23	17.05	2.18	16.8	.1313	.00408	.00147	00261	.00261
0.96	17.7	.0542	.00168	00093	.00075	16.48	14.15	2.33	19.7	.1183	.00367	.00113	.00254	.001178
1.65	14.8	.1115	00346	.00123	.00223	19.48	17.44	2.04	16.3	.1251	.00389	.00147	.00242	.002398
1.77	17.5	.1011	.00314	.00093	.00221	16.30	14.02	2.26	19.9	.1146	.00356	.00113	.00243	.001670
1.24	17.0	.0729	.00226	.00123	.00103	17.05	14.42	2.63	19.2	.1370	.00426	.00147	.00278	.002030
1.45	18.2	.0797	.00248	.00093	.00155	15.79	13.64	2.15	20.5	.1049	.00326	.00113	.00213	.002167
1.44	17.1	.0842	.00261	.00123	.00138	16.65	14 15	2.70	19.5	.1386	.00430	.00147	.00383	.002497
2.43	16.5	1473	.00457	.00093	.00364	17.05	15.15	1.90	18.7	.1016	.00318	.00113	.00203	.00212
1.59	19.4	.0620	.00255	.00123	.00132	14.71	11.90	2.81	22.9	.1232	.00383	.00147	.00236	.001907
0.63	17.0	.0486	.00152	.00093	.00059	17.24	15.62	1.62	18.3	.0885	.00278	.00113	.00163	.001343
1.26	18.3	0686	.00214	.00123	.00091	15.79	14.42	1.37	19.9	.0688	.00214	.00147	.00067	.001683
													Westbound Average	.002963
													Eastbound Average	.003224
2.39	17.4	.1374	.00426	.00093	.00333	16.13	12.60	3.63	21.2	.1665	.00517	.00113	.00404	.003710
-	-		-	-	-	16.48	12.20	4.28	21.4	.200	.00621	.00147	.00474	.004740
2.30	18.2	1420	.00441	.00093	.00348	17.44	15.00	2.44	18.6	1312	.00407	.00113	.00294	.003747
3.03	17.5	.1752	.00544	00123	.00421	15.96	12.30	3.66	21.6	.1694	.00526	.00147	.00379	04527
3.21	20.4	1573	.00489	.00093	.00396	13.27	9.15	4.12	27.7	.1487	.00462	.00113	.00349	.004193
3.33	16.5	.2018	.00627	.00123	.00504	16.67	13.39	3.28	20.2	.1624	.00504	.00147	.00357	. 04313
1.92	19.4	.0990	.00307	.00093	.00214	14.66	13.04	1.62	21.8	.0697	.00216	.00113	.00103	.002120
1.19	17.4	.0684	.00212	.00123	.00089	16.67	13.89	2.78	19.6	.1404	.00436	.00147	.00289	.001837
1.15	19.3	.0585	.00182	.00093	.00089	15.00	13.27	1.73	21.3	.0812	.00252	.00113	.00139	.001873
1.52	17.8	.0854	.00265	.00123	.00142	16.13	14.02	2.11	19.5	.1082	.00336	.00147	.00189	.001807
1.65	24.9	.0743	.00231	.00093	.00138	11.19	8.77	2.42	30.8	.0790	.00245	.00113	.00132	.001457
1.16	20.4	.0569	.00177	.00123	.00054	14.15	11.28	2.87	23.9	.1201	.00373	.00147	.00226	.001713
1.13	19.3	.0585	.00182	.00093	.00089	15.00	13.16	1.64	21.4	.0860	.00267	.00113	.00154	.001383
2.05	20.4	.0995	.00309	.00123	.00186	13.76	12.00	1.76	23.4	.0752	.00234	.00147	.00087	.001680
1.77	17.5	.1011	.00314	.00093	.00221	16.30	15.00	1.30	19.2	.0677	.00210	.00113	.00097	.001637
1.11	18.0	.0617	.00192	.00123	.00069	16.13	13.51	2.62	20.4	.1284	.00399	.00147	.00252	.001707
													Westbound Average	.002540
													Eastbound Average	.002791
3.86	24.6	.1569	.00487	.00093	.00394	10.56	8.38	2.18	32.1	.0679	.00211	.00113	.00098	.002973
2.45	17.2	.1424	.00442	.00128	.00319	16.30	12.60	3.80	21.2	.1792	.00557	..00147	.00410	.004047
2.60	22.0	.1136	.00353	.00093	.00260	12.60	11.28	1.22	26.3	.0482	.00150	.00113	.00037	.002163
2.02	18.1	.1118	.00347	.00123	.00224	15.63	12.50	3.13	21.6	.1449	.00450	.00147	.00303	.003423
1.97	24.1	.0817	.00254	.00093	.00161	11.54	10.07	1.47	27.9	.0527	.00164	.00113	.00051	.001207
1.05	16.9	.0621	.00193	.00123	.00070	17.24	16.13	1.11	18.0	.0617	.00192	.00147	.00045	.001277
2.19	22.9	.0956	.00297	.00093	.00204	12.10	10.87	1.23	26.2	.0469	.00146	.00113	.00033	.001257
1.96	21.5	.0912	.00283	.00123	.00160	13.04	9.87	3.17	26.7	.1187	.00369	.00147	.00222	.002280
1.70	20.6	.0825	.00256	.00093	.00163	13.76	12.61	1.15	22.8	.0604	.00156	.00113	.00043	.001523
0.98	19.2	.0510	.00158	.00128	.00035	15.15	12.50	2.65	21.9	.1210	.00376	.00147	.00229	.001403
													Westbound Average	.0018446
													Eastbound Average	.002486

SUMMARY

Average Resistance not Including Grade Resistance

	W.Bound (A)	E.Bound (B)	Excess E.Bound over W.Bound (B)-(A) (C)	lbs.per ton (D)	% (E)
1-Car Cuts	.002963	.003224	.000261	0.522	8.8
2-Car Cuts	.002540	.002791	.000251	0.502	9.9
3-Car Cuts	.001846	.002486	.000641	1.282	34.6
4-Car Cuts	.002095	.002510	.000415	0.830	19.8
Average	.002361	.002753	.000392	0.784	16.6

A

Table 2 COMPUTATION OF RESISTANCE BY COMPARISON OF VELOCITIES ON FIRST AND LAST SECTIONS.

Car No.	Load or Empty	Track	*Average Velocity Sta. 0 to Sta. 5	Sta. 9 to Sta. 12	(4) minus (5)	Retardation **Time	Per Sec.	Total	Resistance Grade	Oth
1	2	3	4	5	6	7	8	9	10	11
	Single Car Cuts									
14204	E	W-bd.)	22.39	12.71	9.68	51.5	0.1880	.00584	.00101	.00483
		E-bd.)	19.25	5.84	13.39	79.3	0.1689	.00525	.00125	.00400
15081	E	W-bd.(	21.74	13.51	8.25	51.0	0.1614	.00501	.00101	.00400
		E-bd.(	19.23	8.82	10.41	69.6	0.1495	.00464	.00125	.00339
13953	E	W-bd.)	19.74	7.21	12.53	70.0	0.1790	.00556	.00101	.00455
		E-bd.)	23.44	12.40	11.04	51.5	0.2152	.00668	.00125	.00543
15040	L	W-bd.(	18.07	14.15	3.92	54.3	0.0722	.00224	.00101	.00123
		E-bd.(	22.73	17.44	5.29	44.8	0.1181	.00367	.00125	.00242
13409	L	W-bd.)	18.75	14.02	4.73	53.7	0.0881	.00274	.00101	.00173
		E-bd.)	20.00	14.42	5.58	51.9	0.1075	.00334	00125	.00209
14262	L	W-bd.(	19.23	13.64	5.59	55.2	0.1013	.00314	.00101	.00213
		E-bd.(	20.00	14.15	5.85	52.3	0.1118	.00347	.00125	.00222
15047	L	W-bd.)	20.27	15.15	5.12	60.3	0.1018	.00316	.00101	.00205
		E-bd.)	18.07	11.90	6.17	59.7	0.1034	.00321	.00125	.00196
15025	L	W-bd.(	19.48	15.62	3.86	61.3	0.0752	.00234	.00101	.00133
		E-bd.(	19.48	14.42	5.06	54.7	0.0925	.00287	.00125	.00162
									Westbound Average	.00273
									Eastbound Average	.00289
	Two Car Cuts									
15081	E	W-bd.)	22.39	15.00	7.39	49.1	0.1505	.00467	.00101	.00366
14324	E	E-bd.)	22.06	12.30	9.76	53.6	0.1821	.00566	.00120	.00446
13064	E	W-bd.(	19.74	9.15	10.59	64.8	0.1634	.00507	.00101	.00406
13953	E	E-bd.(	22.39	13.39	9.00	50.9	0 1768	.00549	.00120	.00429
13906	L	W-bd.)	18.75	13.04	5.71	58.3	0.0979	.00304	.00101	.00203
14273	L	E-bd.)	19.23	13.89	5.34	53.4	0.1000	.00311	.00120	.00191
15040	L	W-bd.(	18.52	13.27	5.25	58.0	0.0905	.00281	.00101	.00180
13409	L	E-bd.(	19.23	14.02	5.21	53.6	0.0972	.00302	.00120	.00182
13873	L	W-bd.)	14.85	8.77	6.08	77.0	0.0790	.00245	.00101	.00144
14262	L	E-bd.)	17.24	11.28	5.96	62.8	0.0949	.00295	.00120	.00175
15047	L	W-bd.(	17.65	13.16	4.49	58.5	0.0768	.00239	.00101	.00138
14197	L	E-bd.(	17.85	12.00	5.85	61.8	0.0914	.00284	.00120	.00164
15025	L	W-bd.)	19.74	15.00	4.74	52.6	0.0901	.00280	.00101	.00179
13084	L	E-bd.)	18.75	13.51	5.24	55.1	0.0951	.00295	.00120	.00175
									Westbound Average	.00230
									Eastbound Average	.00251
	Three Car Cuts									
14204	E									
15081	E	W-bd.)	17.44	8.38	9.06	74.7	0.1213	.00377	.00101	.00276
14324	E	E-bd.)	21.43	12.50	8.93	53.4	0.1673	.00519	.00113	.00406
13064	E	(								
13953	E	W-bd.(	17.65	11.28	6.37	65.8	0.0968	.00301	.00101	.00200
13904	L	E-bd.(	20.55	12.50	6.05	55.5	0.1450	.00450	.00113	.00337
14273	L	)								
15040	L	W-bd.)	15.15	10.07	5.08	73.0	0.0696	.00214	.00101	.00115
13409	L	E-bd.)	20.00	16.13	3.87	50.6	0.0765	.00238	.00113	.00125
13873	L	(								
14262	L	W-bd.(	15.79	10.87	4.92	69.1	0.0712	.00221	.00101	.00120
15047	L	E-bd.(	17.24	9.87	7.37	66.9	0.1102	.00342	.00113	.00229
14197	L	)								
15025	L	W-bd.)	17.65	12.61	5.04	61.6	0.0818	.00254	.00101	.00153
13084	L	E-bd.)	17.44	12.50	4.94	59.0	0.0837	.00260	.00113	.00147
									Westbound Average	.00172
									Eastbound Average	.00248
	Four Car Cuts									
Caboose		)								
14204	E	W-bd.)	20.27	11.45	8.82	59.1	0.1492	.00463	.00101	.00362
15081	E	E-bd.)	22.06	13.89	8.17	48.4	0.1688	.00524	.00113	.00411
14324	E	)								
13064	E	(								
13953	E	W-bd.(	18.07	12.82	5.25	59.6	0.0881	.00274	.00101	.00173
13906	L	E-bd.(	21.15	15.00	6.15	49.7	0.1233	.00383	.00113	.00270
14273	L	(								
15040	L	)								
13409	L	W-bd.)	13.89	7.43	6.46	88.6	0.0729	.00226	.00101	.00125
13673	L	E-bd.)	17.65	11.81	5.84	62.2	0.0939	.00292	.00113	.00179
14262	L	)								
15047	L	(								
14197	L	W-bd.(	16.48	11.36	5.12	67.3	0.0761	.00236	.00101	.00135
15025	L	E-bd.(	19.48	14.71	4.77	52.1	0.0916	.00284	.00113	.00171
13084	L	(								
									Westbound Average	.00198
									Eastbound Average	.00257

Car No.	Load or Empty	Track	Time in seconds from Sta. 0 to Sta. 3	Sta. 6	Sta. 9	Sta. 12	Average Velocity Sta. 0-3	Sta. 3-6	Retardation (6) minus (9)	Time (5)/2	Per Sec. 10/11	Resistance Total (12)/32.2	Grade	Other	Average Velocity Sta. 3-6	Sta. 6-9
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Four Car Cuts														
Caboose)																
14204)	E	W-bd.	14.8	32.0	54.4	79.8	20.27	17.44	2.83	16.0	.1769	.00549	.00093	.00456	17.44	14.02
15081)	E	E-bd.	13.8	28.4	44.4	66.0	22.06	20.27	1.79	14.2	.1260	.00391	.00070	.00321	20.27	18.76
14524)	E															
13064(	E															
13953(	E	W-bd.	16.6	36.0	56.2	79.6	18.07	16.30	1.77	17.5	.1011	.00314	.00093	.00221	16.30	14.15
13906(	L	E-bd.	14.2	29.8	46.8	66.6	21.13	19.23	1.90	14.9	1275	.00396	.00070	.00326	19.23	17.66
14273(	L															
15040)	L															
13409)	L	W-bd.	21.6	47.8	78.2	119.6	13.89	11.45	2.44	23.9	.1021	.00317	.00093	.00224	11.45	9.55
13873)	L	E-bd.	17.0	36.4	58.0	83.4	17.88	15.46	2.19	18.2	.1203	.00374	.00070	.00304	15.48	13.89
14262)	L															
15047(	L															
14197(	L	W-bd.	18.2	39.4	63.2	69.6	16.48	14.16	2.33	19.7	.1183	.00367	.00093	.00274	14.16	12.60
15025(	L	E-bd.	15.4	32.0	49.6	70.0	19.48	18.07	1.41	16.0	.0881	.00274	.00070	.00204	18.07	17.05
13084(	L															

Retardation (16) minus (17)	Time (6-4)/2	Per Sec. 18/19	Resistance Total (20)/32.2	Grade	Other	Average Velocity Sta. 6-9	Sta. 9-12	Retardation (24) minus (25)	Time (7-5)/2	Per Sec. (28)/(27)	Resistance Total (28)/32.2	Grade	Other	Ave. Resistance except grade (15)+(23)+(31)/3
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
3.42	19.3	.1772	.00550	.00093	.00457	14.02	11.46	2.57	23.8	.1080	.00335	.00113	.00222	.003783
1.52	15.4	.0987	.00307	.00123	.00184	18.75	13.89	4.86	18.8	.2585	.00803	.00147	.00656	.003870
2.15	19.8	.1086	.00337	.00093	.00244	14.16	12.82	1.33	22.5	.0596	.00186	.00113	.00072	.001790
1.58	16.3	.0969	.00301	.00123	.00178	17.65	15.00	2.66	18.5	.1432	.00445	.00147	.00298	.002673
1.90	28.8	.0660	.00205	.00093	.00112	9.55	7.43	2.12	36.9	.0591	.00184	.00113	.00071	.001357
1.57	20.6	.0766	.00238	.00123	.00115	13.89	11.81	2.08	23.5	.0885	.00275	.00147	.00128	.001823
1.55	22.6	.0689	.00214	.00093	.00121	12.60	11.36	1.24	25.1	.0494	.00153	.00113	.00040	.001460
1.02	17.1	.0596	.00185	.00123	.00062	17.06	14.71	2.34	19.0	.1232	.00385	.00147	.00238	.001673
													Westbound Average	.002095
													Eastbound Average	.002610

SUMMARY

	Westbound (A)	Eastbound (B)	Excess East over West (B - A)	Lbs. per T.	%
1-Car Cut	.002731	.002891	.000160	0.320	5.9
2-Car Cuts	.002309	.002517	.000208	0.416	9.0
3-Car Cuts	.001728	.002488	.000760	1.520	44.0
4-Car Cuts	.001987	.002577	.000590	1.180	29.6
Total	.008755	.010473	.001718		
Average	.002189	.002618	.000429	0.858	19.6

*See Cols. (8) and (25), Table 1.

**See Table 1, Cols. $\frac{(7)+(6)-(4)}{2}$

Dear Professor Talbot:

"Professor E. G. Young, Mr. N. H. Barnard and myself have studied the statement and the tables which accompanied Mr. Paul Chipman's letter to you dated August 13 concerning the tests made on the Pere Marquette Railway to determine the relative resistance of trains running on standard track and on their concrete roadbed track at Beech, Michigan.

"We understand the test procedure and we think it correct although there is considerable likelihood of error in using stop watches and there is at least a possibility of considerable error in the determination of grade.

"The method which has been used in calculating the results is correct. We have checked the calculations in six instances chosen at random. These items are underlined in red on the tables. We find no errors. If the six items are characteristic, the calculations are well made.

"As to the validity of the method of presenting the results, we have a good deal of doubt, as obviously Mr. Chipman himself has. We have plotted all the results from Table 1 and Table 2 on the four sheets of cross-section paper which accompany this letter. In the plots applying to Table 1 there are a good many values of resistance less than .001 lb. per pound which is equivalent to 2 lb. per ton. We are suspicious of all such values. In fact, any resistance value under 2½ lb. per ton is extraordinary to say the least and is probably wrong. Of course, if there were an equal number of extremely high points to counterbalance these low ones the average might still be acceptable, but the excessively high points seem to be much fewer in number. Certainly the process of averaging values which vary as widely as they do in the plots on these two sheets, is open to serious objection.

"We are sure that a good deal of this divergence among values would be eliminated or at least greatly reduced, if the test runs were separated with respect to the weight of the cars involved. Car weight has a much greater influence on resistance than has the kind of track or the speed (within the speed limits of these tests). I would strongly advise therefore that the data be separated with respect to car weight. No weights are given in the material at our disposal. All we know is that the cars are designated as 'empty' or 'loaded.' Assuming that all empty cars are very nearly alike in weight and assuming further that the loaded cars are all about the same weight, we would certainly segregate the data into tests applying to loads and empties. There are a few runs in which the 'cuts' of cars included both empties and loads. These instances are not very numerous but here again if the average weights of these groups are nearly the same from test to test, they might constitute a third group for separate presentation. Professor Young has tried to make this separation on the basis of empties and loads in a memorandum which he prepared for my benefit, and of which I am attaching a copy. This memorandum, I think, will serve to make clear many of the details concerning the matters with which I am here dealing in general terms.

"I would call attention particularly to Professor Young's illustration of the magnitude of the errors in final resistance values which may arise from an error of only one-fifth of a second in the measurement of time under the conditions which prevail in these tests. Some of these errors in time observations can doubtless be discovered and they might be eliminated by the procedure which Professor Young suggests in the last paragraph of his memorandum. For every run there were four observations of time made by different individuals. If different observations are plotted it would be generally easy to draw a curve, remembering that this curve would pass through the origin of co-ordinates. Such a curve would be pretty sure to disclose one incorrect reading out of the four. If two readings were incorrect, the process might not be so effective. It would be worthwhile, we think, to check the time observations in this way and then repeat the calculations using time from the curve instead of the original observations of time.

"As far as the determination of grade is concerned, we have no means of knowing how accurately the work was done but the memorandum shows how great an error may result from a small error in leveling. If Mr. Chipman is not satisfied with the original work in this respect, I suppose it could still be repeated without sacrificing the balance of the data.

"I would sum up our impressions of the report and our suggestions as follows:

1. "Notwithstanding the doubts and objections which I have expressed above, we think the test results can probably be put into shape to warrant their publication. No matter how we handle them, they show a fairly consistent reduction of resistance on the concrete roadbed and that fact is important enough and of such interest as to warrant the publication of results which are not in all respects conclusive. If I were publishing them, I should, of course, be careful to state the probable limits of accuracy and to make it clear that the results are not thoroughly conclusive nor final.

2. "We think the presentation can be much improved by separating the data with respect to car weight.

3. "Some of the errors in stop watch readings may be eliminated by a suggestion made by Professor Young at the end of his memorandum.

4. "If there is any doubt about the grade determinations, they might be remade.

Very truly yours,

(Signed) E. C. Schmidt.

(Oct. 1, 1928.)"

RESISTANCE ON CONCRETE-BED TRACK, PERE MARQUETTE RAILWAY

1. "Method of making tests and taking data is fully described in the memorandum accompanying the test results and calculations. Test data taken consist only of the times at stations designated as 3, 6, 9 and 12; that is, the time to reach these points after leaving station 0.

2. "The mathematical process used is as follows:

"It is assumed that the resistance throughout each 300-foot section is constant, hence the retardation during the section is constant.

"The average V in feet per second is $\frac{300}{t_3 - t_0}, \frac{300}{t_6 - t_3}$, etc.

"The retardation from the center of the first section to the center of the second section is therefore:

$$a = \frac{\frac{300}{t_3 - t_0} - \frac{300}{t_6 - t_3}}{\frac{t_6}{2}} \text{ feet per second per second.}$$

Since $F = Ma = \frac{Wa}{32.2} = W\frac{a}{32.2}, \frac{F}{W} = \frac{a}{32.2}$, the retarding force in pounds per *pound.*

3. "Calculations. We have checked the calculations at six points as underlined in red in the tables, and find the work to have been correctly done at all these points. One sample calculation has been shown in full on attached sheet.

4. "The Process. The process appears to be entirely valid: the slope of the resistance curve at the speeds involved (5-18 m. p. h.) is such that I think the process of averaging is legitimate enough. It is to be noted that the total length of the test section was 1200 feet, hence there was 126 feet of concrete track beyond the end, into which the cars ran at the start of the test; this would not be sufficient for the four-car cut, that is, when the first car of the cut passed into the test section the fourth car will still be running on ordinary track. This seems a rather trifling matter, however, in view of the small number of points affected.

5. "Results. The results of the investigation are extremely erratic. Reduced to more familiar figures, I note resistances found were all the way from 0.66 lb. per ton to 14.08 lb. per ton, and I consider the method of combining results by simply averaging all the values for the two tracks respectively to be indefensible.

"In the first place, the results show very clearly the great difference between the empty and loaded cars. It is unfortunate that we have no car weights at all, but at least the results can be classified as *empty* and *loaded*. In the case of the three and four car cuts, some of these were mixed, giving a third classification either to be used or thrown away.

"On account of the variation in speed—5 to 18 m. p. h.—it might be expected that the speed should have been considered in some way. The reason for not doing this is evident, however, in view of the large and unexplained variations in other directions—much greater than speed variation would explain. As a matter of fact, the plots we made do not show any speed relation.

"Thirdly: No resistance value working out at two pounds per ton or less can have any foundation of fact—with ordinary car journals, at least. (Minimum resistance for 75-ton car, Bull. 43, 3 lb.) Twenty-six out of 154 results in Table 1 fall in this class. It may be urged that these represent personal errors in observation, and that these low points are balanced by high points and should therefore be used in the average. It is true that there are a number of obviously wild high points, but not as many as the wild low ones.

"In order to see what the results actually were, or how we would interpret them, we have plotted all of those from Tables 1 and 2. These are plotted in terms of the original data, but here summarized in terms of pounds per ton. The figures selected represent the most important group or level of points in every case, the wild points being eliminated from the average. This method, of course, has a large personal factor. The summary for Table 1 follows:

	Eastbound Track (Ordinary) Lb./Ton	*Westbound Track (Concrete) Lb./Ton*	*Decrease on Westbound Track*
Single Empty	4.9 (8/13)	4.6 (8/15)	0.3
Double Empty	4.5 (4/ 7)	3.7 (4/ 9)	.8
Three Empties	8.0 (2/ 3)	8.0 (1/ 3)	.0
Four Empties	4.2 (2/ 3)	4.4 (1/ 3)	—0.2

	Eastbound Track (Ordinary) Lb./Ton	*Westbound Track (Concrete) Lb./Ton*	*Decrease on Westbound Track*
Single Loads	2.4 (8/19)	2.0 (5/19)	0.4
Two Loads	4.2 (7/15)	3.0 (6/15)	1.2
Three Loads	4.4 (2/ 9)	3.0 (4/ 9)	1.4
Four Loads	4.2 (2/ 6)	3.5 (0/ 6)	0.7

"The fraction is to be interpreted as follows: 2/6 means 'two tests out of six gave results varying not more than 10 per cent from the average selected.' The fraction is a measure of the validity of the conclusion, a large denominator and a value approaching unity representing the most dependable results.

"There is no statement shown giving the method of obtaining the grade resistance, except that levels were run on the tracks. However, the variation in the grade resistance figures show that account was taken of the varying length of the cuts, etc. The most accurate possible leveling is essential, for in the case of the loaded cars, the grade resistance approaches half of the total; an error of six inches per mile results in an error of 10 per cent in the resistance value.

"The most important variation to be considered is that of errors of timing. The common disagreements among expert track timers of 1/5 second wrecks the results in the present case, as witness the following:

	Correct Time	*Error 0.2 sec. (in T-3)*	*Remarks*
T-0	0	0	Assumed example — not from the tables given.
T-3	14	13.8	
T-6	29	29	
Time for first section 0-3	14 sec.	13.8 sec.	
Mean speed 0.3	21.43 f.p.s.	21.74 f.p.s.	
Mean speed 3-6	20.00 f.p.s.	19.73 f.p.s.	
Reduction	1.43 f.p.s.	2.01 f.p.s.	
Time (T-6 ÷ 2)	14.5 sec.	14.5 sec.	
Retardation, f.p.s.^{2}	0.985	1.385	
Retarding force = retardation ÷ 32.2.	0.00306	0.00431	
Less grade resistance	0.00100	0.00100	
Net resistance	0.00206	0.00331	
Error	......	60%	

"Table 2 covers the conditions of no intermediate reading—that is, the reduction of speed from the middle of the first section to the middle of the last section. In this case the times involved are longer, and stop-watch errors of the same absolute value are of proportionately less relative importance. The result is a much better distribution of the points, the range being from 0.00120 to 0.00543 in place of from 0.00033 to 0.00708 for Table 1. I think the averages in this case have more validity (except of course the averaging of light and heavy cars together) and no points need be thrown out except for the mixed cuts. The averages are as follows:

	Concrete Base Track	*Ordinary Track*	*Decrease*
Loads	.00150 (3 lb. ton)	.00175 (3.5)	0.5
Empties	.00390 (7.8 lb. ton)	.00410 (8.2)	0.4

"The reductions of 14 and 5 per cent, respectively, for the concrete track seem quite reasonable, and I think the results of Table 2 are a much better exhibit and are fairly conclusive.

"I think that the entire investigation could be recalculated profitably from new time series curves, made up by plotting for each run the observed times, correcting the series by a smooth curve, and taking the time values for the calculations from these curves instead of using the original stop-watch data.

"(Signed) E. G. Young.

"August 29, 1928."

Undoubtedly an investigation of stresses in rail on the Pere Marquette installation as compared with stress in rail of adjacent track would develop interesting facts. Such work is beyond the ability of this Committee which hopes that the consideration being given to this feature by the Board of Direction will result in such an investigation.

This Committee's efforts were directed particularly to investigation of permanent roadbed constructed without ballast. However, reports were received on some installations of concrete slabs under ballasted track. The Long Island Railway confirmed statement made on its installation by Sub-Committee No. 3 of Roadway Committee in 1928 Proceedings. The New York Central Railroad Company reports that records are being kept of maintenance costs of their installation at Staatsburgh, New York, but do not as yet cover a long enough period to give fair comparisons with cost of standard track maintenance.

Numerous installations of concrete slabs under railway crossings have been made by Elgin, Joliet & Eastern Railway and also by the St. Louis Terminal Railroad Association of St. Louis under crossings and switches, both having gratifying results. The Norfolk & Western Railway has developed a concrete floor with ballast for use in tunnels, which is proving successful. The Chicago Union Station installation under somewhat extreme conditions has been justified. At its new Randolph Street Terminal in Chicago, the Illinois Central Railroad is using a slab construction, the top of which is about 10 feet below level of Lake Michigan not far distant. The slab is 12 inches thick reinforced both ways top and bottom with ⅝ inch round bars 12-inch centers. The distance top of rail to bottom of slab is 2 feet 2 inches except where space is left between pairs of tracks for drainage on top of slab. Longitudinal expansion is provided for by 1-inch joints, composed of Carey's Elastite and lead plate which divide the slab into 200-foot sections. Tile drains are placed in the sub-grade.

This report is submitted as information with suggestion that the subject be reassigned.

Appendix E

(5) THE CONDITIONS WHICH SHOULD GOVERN THE USE OF CULVERTS

A. E. Botts, Chairman, Sub-Committee; W. M. Neptune, W. G. Brown, J. S. Goodman, L. C. Miller, H. T. Livingston, E. H. Olson.

The definition of a Culvert, as given on page 369 of the 1921 issue of the Manual, reads:

CULVERT.—A covered passage for water under a roadway or embankment.

Our subject is the use of culverts and not bridges, but we must mention the latter, and start by noting the factors used to determine the use of a culvert as against a bridge.

One usually thinks of a bridge as a structure spanning an opening of major importance, whereas a culvert, while it may be imposing at times, is generally thought of as being used for a minor opening. Generally speaking, no other consideration but of plain every day suitability will determine whether a bridge or culvert be used. It is quite likely that some one condition would determine the type, or if not, the cost of one or the other would be the determining element.

In general, it might be said that if the crossing is very broad, a bridge should be used, particularly if the opening is relatively shallow with considerable water flowing. The spans of the bridge may then be made much longer than those on a multiple culvert and, consequently, less supports are needed. On the other hand, for a narrow crossing with high banks, a culvert is more suitable, particularly with respect to cost and maintenance. It is generally easier to extend a culvert for future tracks, also where curvature is sharp or multiple tracks are involved culverts are preferable.

The selecting of a culvert is, of course, governed by topography and local conditions, and the type of structure selected depends not only upon the first cost, but renewals and maintenance.

There seems to be a growing tendency of installing culverts in preference to bridges wherever possible, and it has been customary for a number of years to make investigation covering drainage areas and other pertinent features in connection with bridges on some of the railroads in this country, with the idea of making replacements with culverts to reduce maintenance cost.

In determining the size of openings, the first consideration must be given to the volume of water to be taken care of. Usually the first source of information sought is the history of the opening and the high water marks. This data is most valuable and is checked against the various drainage tables, Dun's, Myers, A.R.E.A., etc. In case no historical facts are available, nor high water marks known, dependence is then placed upon the aforesaid drainage tables, together with other known information pertaining to the actual area drained.

Some of the factors considered in determining the type of structure are: Drainage area; prairie, woody or cultivated; rapidity of flow, slopes; height of embankment; possible back water due to excessive rain fall, with respect to damage of adjacent property; concentration of flow to one point to prevent cutting of adjacent land on down stream side, with especial consideration to the legal possibilities of damage; depth of streams at point crossed with relation to surrounding land, permanency and loads and stresses.

It is necessary to give consideration to the character of the underlying soil conditions where pipe is used, in order to avoid possibility of settlement. There are very few localities where conditions are such as to preclude the use of pipe where it is satisfactory for the requirements. Where the bed of the stream is of rock, the arch is a satisfactory waterway, as it gives larger area per unit of volume than the box. Of course, it is more difficult to design and more costly to install, and, except in special cases, seems to be passing into the discard and being superseded by the reinforced concrete box.

Pipe is quite generally used for an opening up to 6 feet in diameter, and beyond this size arches and concrete boxes are used, and, as before mentioned, concrete boxes are preferred.

Type of design is also governed by whether the line is a main track carrying maximum loads or a branch line over which limited loading is prescribed.

The types of culvert construction which are most generally used are cast iron pipe, reinforced concrete pipe, reinforced concrete boxes, masonry arches and corrugated iron pipe.

Cast iron pipe is a material of great value, practically indestructible and makes an excellent culvert, but the consideration of first cost is causing its displacement for use as railway culverts, except in special situations.

Vitrified clay pipe and non-reinforced concrete pipe are not recommended for use under railway tracks.

In determining the use of pipe for culvert purposes, the co-efficient of roughness in the culvert pipe and the formula for carrying capacity of culverts of any length, the magnitude of each hydraulic element involved in the actual discharge of the culvert must necessarily be known. The features governing are:

(1) The mean velocity of the water in the culvert.
(2) The hydraulic gradient showing the friction losses in the culvert.
(3) The head lost at the culvert entrance.

It is our understanding that tests are now being conducted with reference to an expanded outlet, both on concrete boxes and also on culvert pipes of various types. This expanded outlet has the same effect on the culvert as a draft tube has on a turbine and by converting velocity head to pressure head, greater efficiency is secured. However, this increased capacity for any type of culvert is not obtained until the outlet end of pipe is entirely submerged. This type of outlet has additional merit in that the outlet velocities are greatly reduced and the destructive scour, which so often occurs at culvert outlets, is avoided. The diagrams and compilation for concrete box culverts are similar to those for pipe culverts but in the main the results are similar and the increased carrying capacity more than repays for the expense of the expanded or flared outlet.

Friction, resistance to flow through various culverts, may have bearing on the selection of the type to be used. At a recent test between concrete pipe, vitrified clay pipe, and corrugated metal pipe, it showed that the velocity in the concrete pipe was 7.00 feet per second, the vitrified clay pipe has a velocity of 6.98 feet per second, and the corrugated metal pipe had a velocity of 5.96 feet per second. Therefore, it is apparent the smoothness of the walls of the concrete pipe evidently was conducive to the least friction and consequent greater velocity.

In determining to what extent topographical features enter into the type of culverts used, that is: mountainous, desert, swamp, etc., there are a number of theoretical considerations which necessarily should be kept in mind in determining the conclusions, such as density of timber, intensity of rain fall, gradient of area drained, etc. However, the attention given these factors will to that extent affect the compilation of data for which the drainage table has been made. Recommendation for certain size culvert or opening for any given situation, is usually made by a resident engineer whose acquaintance with the particular stream has been fairly extensive, and very likely his decision made or influenced by his knowledge of peculiarities of the drainage area.

We find that the effect of vegetation and timber is not taken into the consideration in the calculation for waterways by many roads, as they go on the theory that it will eventually be cut.

On deserts or semi-arid countries the runoff is affected largely by the proximity of opening to the mountainous country where melting snow or heavy rainstorms may be expected. In swampy country culverts are generally equalizers and there is little or no criterion to determine the proper sizes. Where there is considerable cultivation adjacent to railroad tracks, which is likely to overflow, it is necessary to put in openings large enough to assure a quick runoff when water begins to fall. Desert country is not taken into account because it occasionally rains as heavily on the desert as elsewhere. In considering loads and traffic conditions over proposed openings, it is necessary to see that the intensity of pressure on the underlying soil is safe and that the structure has been properly designed to withstand the superimposed load.

Up to a depth of fill of 15 feet over the culvert, it will be well to calculate for the full dead load, live load and full impact for a width of 13 feet. For depths of fill on the culvert over 15 feet, it will be well to calculate for full dead load and live loads without impact. In figuring the loading of a culvert, it will of course be necessary to make it as strong as the bridges in same territory. All pipes or boxes should be placed a minimum of two feet depth under the ballast. For openings in which this head room cannot be obtained, concrete boxes having sufficient foundation and top strength to carry load under ballast should be used.

One railroad is using Cooper's E-60 loading plus dead load of embankment over same, plus 50 per cent of live load for impact if located within a few feet of base of rail and 25 per cent for impact where in excess of 8 feet or 10 feet below base of rail. If the fill is too low for culvert design to give sufficient cushion between the track and the structure, of course, the bridge will be necessary.

The character of soil or material used in roadway over culverts should be such that it is not easily saturated and of that consistency that it would permit water to run off readily and not conducive of slides, soft spots in track, and water pockets.

An historical record of the behavior of all streams of whatever magnitude, to which ready reference could be had by all responsible for design and maintenance, would be a valuable guide in determining the proper size of opening and the proper type to be used. This record should show all of the usual features of the drainage area, such as size, shape, cultivated or pasture, density of timber or other growth, intensity of rain fall, duration of excessive rain fall, if known, peculiarities of topography, rapidity of runoff, average gradient and all other characteristics affecting design of the crossing. After the new structure has been built the record should be continued, all important happenings, such as high-water marks, washouts, settlements, riprappings, etc., be set down for future reference. If available, the history of the crossing from the date of the construction of the railway should be set down and a description of all subsequent reconstructions should be given together with the dates of the same.

It is a good practice to place all culverts on a grade and to have the last half of the length of culvert on a heavier grade than the first half. This will prevent sag in the event there is a settlement of the culvert under the tracks where the load is heaviest.

This report is offered for information with the recommendation that the subject be discontinued.

Appendix F

(6) DRAINAGE AREAS AND WATER RUNOFF

Noah Johnson, Chairman, Sub-Committee; Hardy Cross, A. C. Clarke, J. A. Given, Daniel Hillman, L. C. Miller, H. W. Legro, J. A. Noble, W. M. Neptune, Thomas Walker.

This Committee has collected a large amount of data on the subject of drainage, but in view of the very complex nature of this subject, and by reason of the variety of conditions to be covered existing in different parts of the country, it has no report to offer for this year other than that of progress.

Appendix G

(7) SPECIFICATIONS FOR METAL CULVERTS FOR RAILROAD USE

W. C. Swartout, Chairman, Sub-Committee, A. A. Johnson, H. W. Legro, O. V. Parsons, T. M. Pitman, Jr., J. R. Wilks.

INTRODUCTION

Your Committee was charged with the duty of preparing specifications for metal culverts for railroad use, which specifications are appended hereto. In carrying out our work we found that such specifications as had been prepared were usually quite incomplete, omitting many essential items. This was due, without question, to the fact that the corrugated culvert was developed by the manufacturers of said products and generally without careful scientific or technical study. Such investigation and study has been given the subject only in the comparatively recent past. We feel that it is only stating a simple fact and giving credit where credit is due to say that practically all of this investigation and research has been financed by and carried out under the auspices of the Research Division of the Armco Culvert Manufacturers' Association, as it is only in the last few years that our Association and kindred technical organizations have seriously gone into the details of manufacture of the sheets for and fabrication of the culverts.

It is therefore our conclusion and recommendation that these specifications as well as those for cast iron culvert pipe be received by the Association as information and held over for one year for further study and criticism by the Association, the Committee retaining jurisdiction, making such further changes as next year's Committee may deem proper, and that they be presented with such further changes for final adoption at the March, 1930, convention.

It is hoped that all members of the Association who have had experience in the use of either of these products will favor us with their comments and criticisms on both specifications to the end that the final adopted specification will not present impossible burdens to the producers, but will yet insure that the user will get a product which will guarantee his getting the service which should reasonably be expected.

From our study it is our recommendation that the minimum gage of sheets to be used for various diameters of corrugated metal culverts under different heights of fill should be as follows:

	Height of Fill from Flow Line of Pipe to Base of Rail				
Dia.	*Fill Under 10'*	*10' to 20'*	*20' to 30'*	*Above 30'*	*Not Under Track*
12"	14	14	14	14	16
18"	14	14	14	14	16
24"	12	12	12	12	14
30"	12	12	12	12	14
36"	12	12	10	10	12
42"	10	10	10	10	12
48"	10	10	8	8	10
54"	8	8	8	8	10
60"	8	8	8	8	8
Over 60"	8	8	8	8	8

SPECIFICATIONS

CORRUGATED METAL CULVERT PIPE FOR RAILROAD USE

GENERAL

1. Pipe shall be straight, of true circular form, of lengths and net internal diameters indicated.

BASE METAL

2. Corrugated metal pipe culverts shall be fabricated from corrugated galvanized sheets, the base metal of which shall be made by the open-hearth process, unless otherwise specified in the contract.

ANALYSIS

3. The base metal shall conform to one of the following chemical requirements. Bidder shall state classification he is bidding on.

CHEMICAL COMPOSITION

Elements	Pure Iron	Copper Bearing Pure Iron	Copper Iron	Copper Molybdenum Iron	Copper Steel	Tolerance by Check Analysis
Carbon, max						
Manganese, max						
Phosphorus, max	.015	.015	.015	.015		
Sulphur, max	.040	.040	.040	.040	.050	.010
Silicon, max						
Copper, min		.20	.20	.40	.20	.02
Molybdenum, min				.05		
Sum of first 5 elements, max		.10	.25	.25	.70	.04
Sum of first 6 elements, max	.10					.04

SHEETS

4. All sheets shall be prime stock, free from injurious defects such as laminations, ragged edges, etc.

Corrugations in sheets shall not exceed two and three-quarters (2¾) inches in width and not less than one half (½) inch in depth. They shall be rolled to an average of not less than U.S. Standard gage per lot weight, subject to the usual tolerance legalized by Act of Congress.

Sheet lengths used in fabricating culverts for the different diameters shall be as follows:

Pipe Diameter	*Sheet Length*	*Pipe Diameter*	*Sheet Length*
8″	29″	42″	138″
10″	35″	48″	156″
12″	41″	54″	1- 80″ and 1-100″
15″	51″	60″	2-100″
18″	60″	66″	1-100″ and 1-119″
21″	70″	72″	2-119″
24″	80″	78″	1-119″ and 1-138″
30″	100″	84″	2-138″
36″	110		

GALVANIZING

Sheets shall be uniformly coated with not less than two (2) ounces of prime quality zinc spelter per square foot of sheet. The galvanizing shall be free from cracks, blisters, pinholes, uncoated spots, or imperfections of any kind, and shall be done in accordance with the Specifications for Galvanizing appearing on page 889 of the Manual of 1921.

RIVETS

5. All rivets shall be of round head type, thoroughly galvanized with zinc spelter, and manufactured of same base metal as sheets and of following sizes:

	Two Thicknesses		*Three Thicknesses*	
	Diam.	*Length*	*Diam.*	*Length*
16 gage sheets..........	5/16″	⅝″	5/16″	⅝″
14 gage sheets..........	5/16″	⅝″	5/16″	¾″
12 gage sheets..........	⅜″	¾″	⅜″	⅞″
10 gage sheets..........	⅜″	¾″	⅜″	⅞″
8 gage sheets..........	⅜″	⅞″	⅜″	1 ″

RIVETING

6. All rivets shall be placed with heads on outside of pipe in the recess of valley of corrugations. Minimum distance from center of rivet to edge of sheet shall not be less than two and one-half (2½) times diameter of rivet. Upsetting of end of rivets on inside of pipe shall give full hemispherical head accomplished in such manner as not to remove or destroy galvanizing, shall insure a tight joint and shall present a neat and workmanlike job. Rivets shall have neat workmanlike, full hemispherical heads or other acceptable form; shall be driven without bending and must completely

fill the hole. Before punching the sheets, the joints or seams shall be tightly and evenly clinched so that the seams are tight, preventing the swelling of rivets between sheets.

Longitudinal joints shall be riveted on not to exceed two and three-quarters (2¾) inch centers, with one row of rivets in pipe twenty-four (24) inches or less in diameter and two rows of rivets in pipe of larger diameters.

Circumferential joints of pipe of all diameter shall be riveted on not to exceed five (5) inch centers.

END REINFORCEMENT

7. Culverts of twelve (12) gage and lighter shall have ends reinforced by an iron rod of not less than seven-sixteenths ($\frac{7}{16}$) inch in diameter, and of a length equal to the circumference of the pipe, folded in the outer edge of sheets forming end sections, by folding or rolling the outer edges of the sheets forming end sections or by other suitable method acceptable to Railroad Company and in such manner that the galvanizing will not be broken or flaked off.

MARKING

8. (a) All sheets shall be conspicuously branded or stencilled on the outside to show manufacturer's name, brand or quality of material, gage of sheet, stock card number (or heat number) of base metal so that complete data covering the manufacturing history of the sheet before galvanizing can be obtained.

(b) All culverts shall have a metal tag of durability equal to that of the culvert riveted to the inside of the pipe on the upstream end which will suitably identify the maker, kind of base metal and year fabricated.

FIELD JOINTS

9. Long lines of pipe may be furnished in sections of greatest length to permit of most economical shipment. There shall be provided suitable bands or coupling devices for joining same securely together in the field.

(a) Bands for pipe shall have lengths and lugs shown in attached table.

Pipe Diameter	*Band Length, Minimum to Engage on Each Section*	*Number of Lugs*
8″ to 15″ both incl.	1 full corrugation	2
18″ to 42″ both incl.	2 full corrugation	3
48″ and larger	3 full corrugation	4

The following gages will be used in constructing bands for Culvert Pipe:

Pipe	*Bands*
8 and 10 gage	Use 12 gage
12 gage	Use 14 gage
14 gage	Use 16 gage

(b) Lugs or fastenings on bands shall consist of forged, fully galvanized wrought iron connecting lugs and draw bolts. Each half of the lug shall be riveted to the pipe with not less than two (2) rivets three-eighths (⅜″) inch in diameter. The draw bolts shall be one-half (½) inch in diameter with not less than three and one-half (3½) inches threaded length.

At the option of the railroad, culverts of fifty-four (54) inch diameter and greater shall be fabricated for field riveting, in which case necessary rivets, as specified under paragraph "Rivets," must be furnished with the pipe and proper appliances for enlarging and tightening sheets of end rings.

GENERAL CARE IN FABRICATION

10. All material shall be so handled and loaded after fabrication that the galvanizing or zinc coating shall not be bruised or broken during the process of fabrication nor afterward.

REJECTION

11. Failure on the part of any pipe delivered to pass these specifications in any particular shall constitute cause for rejection of entire order.

SPECIFICATIONS FOR CAST IRON CULVERT PIPE

MANUFACTURE

The pipe shall be manufactured of cast iron of good quality and of such character as to be strong, tough and of even grain, but soft enough to admit of satisfactory drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal and shall be remelted in a cupola or air furnace. The pipe shall be hub and spigot style of cast iron water pipe or cast iron culvert pipe, or spiral corrugated cast iron pipe, or a ribbed or corrugated cast iron pipe of design approved by Railroad Company, smooth, free from scales, lumps, blisters and other defects impairing its strength or durability, and be round, of uniform physical character, of close grain, and cast vertically. It shall be manufactured in lengths of not less than three (3) feet, and the inner and outer surfaces shall be true, whole, concentric cylinders. This pipe shall be heated to 300 degrees Fahr. and immersed in coal tar varnish so that the result will be a smooth coating on both the inside and outside of the pipe. This coating must be of such a nature that it will be tough, tenacious, not brittle or have any tendency to scale when cold; and such results shall be consistent.

PHYSICAL PROPERTIES AND TESTS

Cast iron culvert pipe shall have minimum thickness of pipe as follows:

Inside Diameter Inches	*Thickness Inches*
12	$\frac{7}{16}$
14	$\frac{7}{16}$
16	½
18	½
20	½
24	$\frac{9}{16}$
30	$\frac{11}{16}$
36	$\frac{13}{16}$
42	$\frac{15}{16}$
48	1¼

No pipe shall be accepted the thickness of which is one-sixteenth ($\frac{1}{16}$) inch less than the thickness herein specified.

The transverse test shall be used to determine the physical properties. The test bar shall be the 1 inch by 2 inches by 28 inches, American Foundrymen's Association Standard rectangular bar. This bar shall be cast vertically in a dry sand mold, coated with a bituminous facing and not cast until the mold is cold. The test bar shall not be tumbled or otherwise treated but simply brushed off before testing.

The test shall be transverse with the bar placed horizontally upon supports 24 inches apart and a concentrated load applied midway between the supports.

The test shall conform to the following requirements as a minimum:

Average load at the center......................	2200 pounds
Average deflection at center....................	0.30 inches

From each melt, test bars shall be poured, the first one five minutes after the first tap and then one bar from each two-hour interval or fraction thereof, throughout the heat.

The pipe shall have sufficient strength so that when tested by the "Three Edge Bearing Method," as specified in the Standard Specifications for Drain Tile, C 14-24, of the American Society for Testing Materials, will show a load-supporting capacity in pounds per linear foot equal to or greater than that obtained by the use of the formula, "W equals 1500 D," in which W equals pounds per foot and D equals the inside diameter of pipe in feet. All pipe shall be carefully examined for defects and sounded with a hammer before shipment. No fillings with metal, cement or other materials, or so-called "burning on" of iron, will be permitted. The castings shall be sound and free from cracks, sandholes, blow holes and cold shots.

INSPECTION AND REJECTION

The manufacturers shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspections shall be so conducted as not to interfere unnecessarily with the operation of the works and shall be made prior to shipment, unless otherwise specified.

All pipe which fails to conform to the provision of these specifications shall be subject to rejection.

Appendix H

(8) DEVELOP BEST METHODS OF PREVENTING THE FORMATION OF WATER POCKETS UNDER THE BALLAST WHEN EMBANKMENTS ARE WIDENED AND/OR RAISED

E. C. Oyler, Chairman, Sub-Committee; H. B. Barry, J. L. Fergus, J. S. Goodman, H. T. Livingston, Thomas Walker.

When embankments are to be widened and/or raised, field studies should be made to determine the elevation of bottom of existing ballast, the filling material, if of impervious nature, to be kept below such ballast level and sloped outward. Any additional filling material needed to complete a higher roadbed section should consist of porous material.

In case porous material is not available for such higher section, longitudinal and cross drains are necessary, the type, sizes, spacing of cross-drains, etc., to be determined by studies of each location. They should be laid at such depth as to be below any movement of the subgrade. Excavation for such drains must be taken out to below frost line, and made to proper grade. Subdrains should be laid to regular line and true grade, and covered with pervious material.

The Committee recommends that this report be accepted for inclusion in the Manual, and that the subject be discontinued.

Appendix I

(9) OUTLINE OF WORK FOR THE ENSUING YEAR

G. S. Fanning, Chairman, Sub-Committee; Anton Anderson, W. S. Morgan, O. V. Parsons, H. E. Tyrrell, E. M. Smith.

The following subjects are offered to the Committee on Outline of Work for their consideration in making their assignments for next year's work:

1. Revision of the Manual.
2. (New.) Methods of laying and maintenance of tile and other drains under the varying conditions along railway track.
3. (Reassign.) Length of life of fence wire and method for increasing the life thereof.
4. (Reassign.) Continue the study of permanent roadbed construction and maintenance of track thereon.
5. (New.) Methods of weed killing—elimination or control.
6. (Reassign.) Develop and report upon drainage areas and water runoff and the proper sizes of waterway openings required under the differing conditions in various parts of the country.
7. (Reassign.) Prepare specifications for cast iron, corrugated iron and other types of metal culverts.
8. (New.) Highway grade crossing planks and substitutes therefor.
9. Outline of work for the ensuing year.

REPORT OF COMMITTEE II—BALLAST

E. I. Rogers, *Chairman;*
C. R. Adsit,
G. G. Amory,
J. S. Bassett,
G. J. Bell,
O. P. Chamberlain,
H. B. Christianson,
W. E. Colladay,
A. P. Crosley,
W. O. Cudworth,
C. E. Dare,
F. T. Darrow,
R. C. Dunlay,
M. I. Dunn,
J. A. Ellis,
W. L. Foster,
C. J. Coon, *Vice-Chairman;*
Daniel Hubbard,
A. A. Johnson,
A. D. Kennedy,
J. E. Lucas,
E. F. Manson,
R. L. McCormick,
H. W. McLeod,
J. F. Montgomery,
P. T. Robinson,
W. A. Roderick,
S. A. Seely,
C. B. Stanton,
H. L. Vandament,
Stanton Walker,
A. H. Woerner,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report on the following subjects:

(1) Revision of the Manual.
The report of the Sub-Committee will be found in Appendix A.

(2) Review and report revision, if necessary, in specifications for washed gravel ballast.
The report of the Sub-Committee will be found in Appendix B.

(3) Continue the study of comparative merits of ballast material, collaborating with Committee I—Roadway and Committee V—Track.
The report of the Sub-Committee will be found in Appendix C.

(4) Make critical study of the cause and effect of pumping joints in railway track and the excess cost of maintenance resulting therefrom, with suitable recommendations for removal of cause, collaborating with Committee I—Roadway and Committee V—Track.
The report of the Sub-Committee will be found in Appendix D.

(5) Continue the study of shrinkage of ballast, collaborating with Committee V—Track.
The report of the Sub-Committee will be found in Appendix E.

(6) Outline of work for the ensuing year.

Action Recommended

1. That the changes in the Manual recommended in Appendix A be approved.

2. That the changes in washed gravel ballast specifications in Appendix B be approved.

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3. That the report of the Sub-Committee (Appendix C) be received as information.

4. That the report of the Sub-Committee (Appendix D) be received as information.

5. That the report of the Sub-Committee (Appendix E) be received as an informatory progress report.

Recommendations for Future Work

1. Revision of the Manual.
2. Conduct tests and continue study of washed gravel ballast to determine the best method of testing for hardness, abrasion and resistance to weathering in order to provide specifications therefor.
3. Continue the study of comparative merits of ballast materials and their effect on operating costs.
4. Continue the study of shrinkage of ballast.
5. Determine the answer to the question: What is ballasted track?

Respectfully submitted,

The Committee on Ballast,

E. I. Rogers, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

M. I. Dunn, Jr., Chairman, Sub-Committee; C. J. Coon, W. O. Cudworth, R. L. McCormick, H. W. McLeod.

No special assignment was carried over by this Committee from last year.

Proof sheets of all matter to be contained in the Ballast section of the 1929 edition of the Manual were checked over by the Committee to insure inclusion in proper sequence of matter adopted since publication of the 1921 edition. Some changes in sequence were made on the proof sheets in order to present the matter more clearly and the few typographic errors noted were corrected. Proof sheets were then returned to the Association Secretary.

It is recommended that the definition of "Foul Ballast" be revised to assign contributary fouling to disintegration of the ballast itself. This definition is found on page 69, 1921, Manual.

Present Form	*Proposed Form*
Foul Ballast.—Ballast which has lost its porosity through the filling up of the voids by cinders, coal dust, dirt or other foreign matter.	Foul Ballast.—Ballast which has lost its porosity through the filling up of the voids by cinders, coal dust, disintegration of the ballast itself, dirt or other foreign matter.

It is recommended that paragraph three (3) of the section relating to Proper Depth of Ballast, page 79, of 1921 Manual, be revised as follows, to render same more applicable to all climatic conditions.

Present Form	*Proposed Form*
(3) These depths are required, under the conditions named, to support the track structure; to provide good initial drainage; to provide against upheaval by frost; to serve as a cushion for the track.	(3) These depths are required, under the conditions named, to support the track structure; to provide good initial drainage; to reduce upheaval by frost; to serve as a cushion for the track.

Appendix B

(2) REVIEW AND REPORT REVISIONS, IF NECESSARY, IN SPECIFICATIONS FOR WASHED GRAVEL BALLAST

C. B. Stanton, Chairman, Sub-Committee; J. S. Bassett, O. P. Chamberlain, C. E. Dare, W. L. Foster, H. L. Vandament, Stanton Walker.

Your Committee reports the following progress on the work assigned:

The following Questionnaire was sent to the membership:

QUESTIONNAIRE ON SPECIFICATIONS FOR WASHED GRAVEL BALLAST

(1) Is your road using washed gravel ballast?
(2) Are the Association's specifications in use?
(3) Are the tests recommended by the Association in use?
(4) Are the tests in use other than the Association's?
(5) What changes do you suggest in the Association's specifications?
(6) What proportion of the various sizes of gravel constitute your ballast?
(7) Does your railroad experience difficulty in obtaining conformity to its specifications?
(8) Please furnish a copy of your railroad's specifications and a description of the tests required.

Fifty replies were received and tabulated. Eleven of the fifteen railroads reporting the use of gravel ballast are using the Association's present specifications in whole or with some modification. Only one of the answering railroads suggests changes in substance.

As a result of careful consideration of the answers to the questionnaire your Committee has rewritten the specifications in order to clarify them and to meet certain objections which have been made to the present form, but has made no important changes of substance.

Your Committee now has under way studies looking toward the development of test methods which will give information covering hardness, abrasion and resistance to weathering. Tests are also being carried out to determine what gradings produce the least voids and offers the greatest resistance to crushing. A further survey is being made of the practices of the various railroads and of the nature of the gravel available for ballast.

Your Committee recognizes that the proposed specifications may not represent the best that can be written. However, it recommends that, pending more complete information, the proposed specifications be continued as tentative for the ensuing year, with the expectation that studies which this Committee has under way will permit it to offer more definite recommendations at the time of the Annual Meeting in 1930.

The present specifications and the proposed revisions follow:

Present Form

1. Gravel for ballast shall be so prepared that all dust, dirt and loam are removed, that all aggregates that will not in every position pass through a 1½ inch ring are either rejected or crushed and returned to the ballast and that the resultant product conform to the following:

2. Where the percentages of crushed material run between nothing and 20, the ratios of various sizes of aggregates to the whole shall be as follows:

1/10 in. to ¼ in.	min. 25%
	max. 40%
¼ in. to ½ in.	min. 20%
	max. 30%
½ in. to 1 in.	min. 20%
	max. 55%
1 in. to 1½ in.	min. 0%
	max. 35%

3. Where the percentages of crushed material run more than 20 and less than 40, the ratios of various sizes of aggregates to the whole shall be as follows:

1/10 in. to ¼ in.	min. 10%
	max. 30%
¼ in. to ½ in.	min. 20%
	max. 35%
½ in. to 1 in.	min. 20%
	max. 60%
1 in. to 1½ in.	min. 0%
	max. 50%

4. Where the percentages of crushed material are more than 40, the ratios of the various sizes of aggregates to the whole shall be as follows:

Proposed Form

1. Gravel for ballast shall be so prepared that all dust, dirt and loam are removed, that all aggregates that will not in every position pass through a 1½ in. ring are either rejected or crushed and returned to the ballast and that the resultant product conform to the following:

2. Where the percentages of crushed material run between nothing and 20, the ratios of various sizes of aggregate to the whole shall be as follows:

Finer than No. 10	max. 3%
1/10 in. to ¼ in.	min. 25%
	max. 40%
¼ in. to ½ in.	min. 20%
	max. 30%
½ in. to 1 in.	min. 20%
	max. 55%
1 in. to 1½ in.	min. 0%
	max. 35%
Larger than 1½ in.	max. 2%

3. Where the percentages of crushed material run more than 20 and less than 40, the ratios of various sizes of aggregates to the whole shall be as follows:

Finer than No. 10	max. 3%
1/10 in. to ¼ in.	min. 10%
	max. 30%
¼ in. to ½ in.	min. 20%
	max. 35%
½ in. to 1 in.	min. 20%
	max. 60%
1 in. to 1½ in.	min. 0%
	max. 50%
Larger than 1½ in.	min. 2%

4. Where the percentages of crushed material are more than 40, the ratios of the various sizes of aggregates to the whole shall be as follows:

¼ in. to ½ in.	min. 20% max. 35%
½ in. to 1 in.	min. 25% max. 60%
1 in. to 1½ in.	min. 5% max. 55%

Test. No. 1. Dust, Dirt or Loam

5. A sample of the prepared ballast containing one-eighth (⅛) cubic foot shall be placed in a water-tight receptacle having a capacity of not less than one (1) cubic foot. Into this receptacle shall then be placed two quarts of clear water, after which the receptacle shall be agitated until the gravel is thoroughly washed. The water shall be drained off immediately and placed in a glass jar and allowed to settle. If the sediment deposited in the bottom of the jar is more than one-half (½) of one (1) per cent of the sample, as determined by weight, the output of the plant shall be rejected until the fault has been corrected.

Finer than ¼ in.	max. 3%
¼ in. to ½ in.	min. 20% max. 35%
½ in. to 1 in.	min. 25% max. 60%
1 in. to 1½ in.	min. 5% max. 55%
Larger than 1½ in.	max. 2%

Test. No. 1. Dust, Dirt or Loam

5. The sample as received shall be moistened and thoroughly mixed, then dried to constant weight at a temperature between 100 and 110 degrees C. (212 and 230 degrees Fahr.) The pan or vessel to be used in the determination shall be 12 inches (30.5 cm.) in diameter by not less than 4 inches (10.2 cm.) deep, as nearly as may be obtained. A representative portion of the dry material weighing not less than 50 times the weight of the largest stone in the sample shall be selected from the sample and placed in the pan which has been dried and accurately weighed. Sufficient water shall be poured into the pan to cover the gravel. The gravel shall be agitated vigorously for 15 seconds with a trowel or stirring rod. After it has settled for 15 seconds the water shall be poured off into the tarred evaporating dish, care being taken not to pour off any gravel. This is repeated until the wash water is quite clear. The washed material shall be dried to constant weight in an oven at a temperature between 100 and 110 degrees C. (212 and 230 degrees Fahr.), weighed, and the net weight of gravel determined. The percentage of clay and silt shall be calculated from the formula:

$$\text{Percentage of Clay and Silt} = \frac{\text{Original weight} - \text{weight after washing}}{\text{Original weight}} \times 100$$

For a check on the results, the wash water shall be evaporated to dryness and the residue weighed:

$$\text{Percentage of Clay and Silt} = \frac{\text{Weight of residue}}{\text{Original weight}} \times 100$$

Test No. 2. Large Aggregate.

6. A sample weighing not less than 150 lb. shall be placed in or on a screen having round holes 1½ inches in diameter. If a thorough agitation of the screen fails to pass through the screen 98 per cent of the material, as determined by weight, the output of the plant shall be rejected until the fault has been corrected.

Test No. 3. Sand

7. One cubic foot of the prepared ballast shall be thoroughly dried, weighed and placed in a screen having ten meshes to the inch and the screen agitated till all particles which will pass have passed through the screen. If the material which passes through the screen exceeds 3 per cent of the original sample, as determined by weight, the output shall be rejected until the fault has been corrected.

Test No. 4. Proportion of Aggregates in Washed, Crushed and Screened Gravel

8. A sample of the prepared ballast, weighing not less than 150 lb. shall be thoroughly dried, weighed and placed on a screen having holes 1½ inches in diameter; all material which can be passed through this screen shall be placed upon a screen having holes 1 inch in diameter; all materials which can be passed through this screen shall be placed upon a screen having holes ½ inch in diameter; all material which can be passed through this screen shall be placed upon a screen having meshes of ¼ inch, and all material which can be passed through this screen shall be placed upon a No. 10 screen, and all material which can be, shall be passed through it.

9. If the ratio of the amount of material retained on the 1½ inch screen to the amount of the sample as a whole exceeds two per cent, the product shall be rejected until the fault has been corrected.

Determination of Grading

6. A sample of the prepared ballast weighing not less than 50 lb. shall be thoroughly dried, weighed and placed on a screen having holes 1½ inches in diameter; all material which can be passed through this screen shall be placed upon screen having holes 1 inch in diameter; all material which can be passed through this screen shall be placed upon a screen having holes ½ inch in diameter; all material which can be passed through this screen shall be placed upon a screen having meshes of ¼ inch, and all material which can be passed through this screen shall be placed upon a No. 10 screen, and all material which can be, shall be passed through it.

10. If the ratio of the amount of material passing the No. 10 screen to the amount of the sample as a whole exceeds 3 per cent, the product shall be rejected until the fault has been corrected.

11. If the ratio of the amount of material retained on each of the screens to the amount of the sample as a whole does not come within the tolerances given above, the material shall be rejected until the fault has been corrected.

Inspection

12. In case inspection develops the fact that the material which has been or is being loaded is not in accordance with these specifications, the inspector shall notify the manufacturer to stop further loading until the fault has been corrected, and to dispose of all defective material that has been loaded in cars, which shall be done at the expense of the contractor.

Measurements

13. When ballast is being paid for by the ton, it is impracticable to weigh each car, the weight per yard shall be obtained by weighing at frequent intervals not less than five cars loaded with the ballast, the contents of which have been carefully measured. The weight per yard obtained by such a test shall be used in figuring the weight per car until another test is made.

14. When ballast is paid for by the yard, the amount shall be determined by weighing each car, where practicable, and applying the weight per yard as determined by frequent tests. When impracticable to weigh each car, the contents of each car will be carefully estimated by comparison with cars, the contents of which have been actually measured.

7. If the ratio of the amount of material retained on each of the screens to the amount of the sample as a whole does not fall within the limits given above, the material shall be rejected until the fault has been corrected.

Inspection

8. In case inspection develops the fact that the material which has been or is being loaded is not in accordance with these specifications the inspector shall notify the manufacturer to stop further loading until the fault has been corrected, and to dispose of all defective material that has been loaded in cars, which shall be done at the expense of the contractor.

Measurement

9. When ballast is being paid for by the ton, and it is impracticable to weigh each car, the weight per yard shall be obtained by weighing at frequent intervals not less than 5 cars loaded with ballast, the contents of which have been carefully measured. The weight per yard obtained by such a test shall be used in figuring the weight per car until another test is made.

10. When ballast is paid for by the yard the amount shall be determined by weighing each car, where practicable, and applying the weight per yard as determined by frequent tests. When impracticable to weigh each car, the contents of each car will be carefully estimated by comparison with cars, the contents of which have been actually measured.

Appendix C

(3) COMPARATIVE MERITS OF BALLAST MATERIALS

Daniel Hubbard, Chairman, Sub-Committee; J. A. Ellis, A. A. Johnson, A. D. Kennedy, J. E. Lucas, S. A. Seely.

The various kinds of ballast in use are listed in the order of their comparative merits in the Manual of the Association as follows:

1—Stone	2—Washed gravel	3—Slag	4—Screened gravel
5—Pit run gravel	6—Chatts	7—Burnt clay	8—Cinders

A discussion of materials follows in the order in which they are given above:

No. 1—Stone—Broken stone prepared under the A.R.E.A. specifications is considered the best ballast for heavy high speed traffic. While first cost of application is greater than that of washed gravel, the work required to keep track in line and surface is less than with gravel ballast. Stone ballast is clean and gives better drainage than any other ballast. The length of time between cleaning of stone ballast depends largely on the character of traffic and density. On coal carrying roads, especially near the source of supply, it is frequently necessary to clean stone every three years. In this operation considerable of the stone is salvaged and can be reused. The cost of cleaning ballast has been considerably reduced of late, due to mechanical and improved methods. Stone ballast is dustless which makes it particularly suitable for lines carrying much passenger traffic. It is found that ballast made from stone of good quality is the most economical and satisfactory in regard to track maintenance. There has recently arisen the question of whether the definition "broken stone" should cover crushed boulders. The Committee desires additional time to study this question.

No. 2—Washed Gravel—This material when prepared to conform to the A.R.E.A. specifications gives a very good ballast for heavy high speed traffic. However, it fouls quickly and cannot be cleaned, it being necessary to replace entirely with new ballast. This material affords good drainage and usually requires renewal in from three to seven years depending on the density of traffic; and on coal carrying roads to the proximity of the mines. The cost of doing the same amount of track work such as surfacing is less in washed gravel than in stone but usually requires more frequent surfacing of track to maintain the same excellence of line and surface.

No. 3—Slag—Slag ballast consists of two kinds, broken and granulated. The broken or crushed slag ballast varies greatly as to hardness, some slag ballast being the equal of broken stone and the cost of maintaining track on such ballast is about the same as stone. Some slag ballast is soft and disintegrates readily under the action of tamping tools. Such slag ballast soon holds water and is not an economical ballast to use as it retards drainage. Granulated slag is much like sand except that it gives better support and drains better. It fouls quickly where traffic is heavy and frequently cements in large pieces, making it difficult to be worked. Before cementing the ballast is easily worked but under heavy traffic frequent working is necessary. Granulated slag is not considered an economical or desirable ballast to use on main track. Metalliferous slag produced by precious metal smelters has recently been brought to the attention of the Committee as making excellent ballast. The Committee desires time to further investigate.

No. 4—Screened Gravel—Practically all gravel ballast that is screened is also washed. Screening alone does not remove the dirt and screening only, unless the deposit is naturally clean, is not an economical proposition. Even where gravel is washed in addition to being screened it has a tendency to creep and work out from under the tie which creates track that is exceedingly hard to keep in line and surface. It is not considered an economical ballast to use except in side tracks and in yards.

No. 5—Pit Gravel—Pit run gravel varies greatly in quality depending on the grading of the material as to sizes of the aggregates and the amount of dirt and other foreign material, which it contains. This ballast is exceedingly difficult to drain, soon becomes foul, and results in very expensive track maintenance. Where it can be found free of dirt and loam and does not contain an excessive amount of sand, it drains fairly well and gives satisfactory service for light traffic, and makes good sub-ballast.

No. 6—Chatts—Chatts are of two classes, that from zinc ore which is coarse and that from lead ore which is fine. The coarse chatts gives good drainage and is easily worked. Fine chatts make a very dusty ballast, clogs quickly affording poor drainage, requires frequent surfacing especially where traffic is heavy. The use of chatts is naturally restricted to the vicinity of the source and is considered an economical ballast to use where more desirable material is not available.

No. 7—Burnt Clay—The use of this material as ballast is restricted to a very small area and it is recommended that this item be eliminated from the ballast classification.

No. 8—Cinders—Cinder ballast consists of locomotive cinders and volcanic ash. A great portion of cinder ballast used on railroads being free from soft coal cinders. The cost of cinders is usually only the cost of hauling material to destination as cinders must be disposed of. When cinder ballast is new it drains well and is easily worked, but disintegrates readily under the action of tamping tools and the impact from heavy loads. It is suitable for ballast on side tracks for lines of light traffic or for track on unstable roadbed. On heavy traffic lines the cost of maintaining cinder ballast is excessive and should not be used. The use of volcanic cinders as ballast material is confined to territory adjacent to the natural deposit. This ballast is heavier and more durable than locomotive cinders. It is easily worked and gives very good drainage. Like gravel it cannot be salvaged but has to be replenished from time to time. It is almost dustless and for this reason meets with favor from a passenger traffic viewpoint.

Appendix D

(4) CAUSE AND EFFECT OF PUMPING JOINTS IN RAILWAY TRACK AND THE EXCESS OF MAINTENANCE RESULTING THEREFROM

W. A. Roderick, Chairman, Sub-Committee; G. G. Amory, H. B. Christianson, F. T. Darrow, R. C. Dunlay, E. F. Manson, J. F. Montgomery.

Your Committee desires to call attention to Appendix E of the Ballast Committee report submitted and as appearing on page 92 of Volume 28 of the 1927 Proceedings, and to Appendix D, page 359 of Volume 29 of the 1928 Proceedings, and the discussions thereto contained in both volumes.

In the report appearing in the 1927 Proceedings, it is apparent the Committee has gone into this subject and as that report indicates, determined five general major causes of pumping joints and the resultants therefrom. The Committee at that time and in that report discussed at some length these various causes and the remedies therefor. It was not at that time and is not now able to present any information which would indicate the excess cost of maintenance of pumping joints over the maintenance of joints which do not pump. The only relative costs are approximations based upon the experience and knowledge of trackmen who have both kinds of track, that there is, of course, an acknowledged increase in maintaining tracks with pumping joints over the cost of maintaining track without pumping joints. This excess cost in maintaining track with pumping joints is from two and one-half times to four times the cost of maintaining track which does not have pumping joints.

The reports heretofore presented have contained remedies which the Committee believes have been followed in many instances as curative measures and which have greatly reduced the pumping of joints, and your Committee believes that if these remedies heretofore recommended would be followed, pumping joints will disappear to a great extent, if not be entirely eliminated.

As a resumé of previous reports, your Committee desires to call attention to the following:

Cause	*Remedy*
(1) Water impounded in roadbed.	(1) Provide proper drainage for roadbed, sub-ballast and ballast.
(2) Foul Ballast.	(2) Either clean the ballast and replace, adding new if required or discard entire foul ballast and provide new, clean ballast.
(3) Creeping Rail.	(3) Anchor the rail more securely than had previously been done.
(4) Light Rail under heavy traffic.	(4) Provide heavier rail.
(5) Improper or insufficient tamping.	(5) Provide sufficient and efficient supervision for this character of track work.

Your Committee believes that if the above remedies are applied to the various causes enumerated, the beneficial results will accrue or the major contributing causes to pumping joints will be eliminated.

It has recently come to the attention of the Committee that there is another contributing cause to pumping joints, i. e., the placing of different kinds of ties in the track structure, for instance, where jack pine, tamarack and softer woods are used in the majority with a small percentage of hardwood ties placed at the joints, the latter cause rigidity at the joint which does not exist at other points throughout the rail lengths, hereby creating a pounding at the joints due to the resistance of the hardwood ties.

Your Committee further learns that this contributing cause has been relieved and pumping joints eliminated by the use of hardwood ties at other points in the rail length than at the joints, using the softwood at the joints.

Appendix E

(5) THE SHRINKAGE OF BALLAST MATERIAL

W. E. Colladay, Chairman, Sub-Committee; C. R. Adsit, G. J. Bell, A. P. Crosley, P. T. Robinson, A. H. Woerner.

This Committee's assignment is to determine the amount of shrinkage of ballast by comparing the yardage paid for at the point of origin with the yardage of the same material tamped and compacted in track under traffic, and is not to be confused with the shrinkage which occurs between the point of origin and the point of application.

The Committee appreciated the fact that the result of any tests to be of value should be obtained from test sections established for that particular purpose. With this object in view specifications were prepared setting forth the requirements for the establishing of a test section. The specifications as finally adopted by the Committee are as follows:

SPECIFICATIONS FOR THE ESTABLISHING OF TEST SECTIONS FOR THE DETERMINING OF SHRINKAGE OF BALLAST UNDER TRAFFIC

Location of Test Sections

The test section should preferably be on a ballast deck trestle, concrete trestle or concrete slab. If none of the above are available, a section may be established on an old seasoned roadbed. The Sub-Committee would prefer the test be made on the ballast deck trestles, concrete trestles or slab as the subgrade would be non-yielding and the results obtained more reliable. Geographical location should be reported.

Length of Test Section

It is not necessary to make these tests on sections of great length. While it would be desirable to make the section as long as possible, the

Sub-Committee feels that if the section was 75 to 100 feet in length, the shrinkage could be more accurately measured than with a section of greater length. It is the consensus of the Sub-Committee that if the section were made sufficiently long to take one car of ballast and accurate measurements taken that the desired information could be obtained.

Preparation of Test Section

All ballast should be removed and accurate cross-section taken on the test section before the test ballast is inserted. In the case of a test section on an old seasoned roadbed the ballast should be removed and the subgrade leveled before the cross-sections are taken. It is extremely important to secure accurate cross-sections and they should be taken at sufficient intervals to insure accurate measurements.

Isolation of Test Section

The ballast in the test section should be isolated from the ballast on either side. This can be accomplished by the insertion of a template at each end of the section. It is suggested that if a one-car section is established that the template be placed at one end of the section and the placing of the ballast continued until the carload is used, when the other template can be placed and the length of the section established.

Placing of Ballast

The ballast should be placed in the track and tamped under the ties in the usual manner.

Cross-Section of Test Section

Immediately after the ballast has been applied and track raised and dressed, accurate cross-sections should be taken so that the yardage can be accurately computed. Where cross-ties are not of uniform length and size measurements should be taken so as to determine the tie space occupied.

Ballast Information Required

Kind of ballast.
Location of pit or quarry.
Weight of car of ballast at pit or quarry.
Weight of car of ballast at destination.
Weight of car light.

Applying Additional Ballast

No additional ballast should be applied to the test section without permission from the officer responsible for the test. All additional ballast should be accurately weighed before applying in track and the weight and date of application reported to the officer in charge of the test.

Progress Cross-Sections

Accurate progress cross-sections should be taken at 30-day intervals during the first 12 months and at 60-day intervals until shrinkage has stopped. Before taking the cross-sections the ballast should be dressed to uniform section.

Tonnage Over Test Section

Equally important with the keeping of accurate records of the volumetric change in the ballast on the test section, the tonnage moving over the section should be reported.

Copies of the specifications were sent to all members of the Ballast Committee, it being the consensus of the Committee that if its members undertook the establishment of a test section results would be obtained that would be representative of the shrinkage occurring in various kinds of ballast and under variable loads.

In answer to the appeal to the Ballast Committee to establish Sections, 10 railroads agreed to make tests on their respective roads.

At the time this report is being written four sections have been established, three on ballast deck bridges and one on a seasoned roadbed. Other sections will be established this fall or early spring.

The Committee is receiving monthly reports of these tests but it is their opinion that inasmuch as the tests are not completed it would not be advisable to give to the Association results of these few incomplete tests. The Committee suggests that the subject be continued for another year so that the report will reflect the results of a number of tests rather than a few.

The Committee feels that it is highly desirable to have a large number of tests made and they ask and urge other members of the Association other than the members of the Ballast Committee to co-operate with this Committee in establishing test sections according to the specifications prepared for that purpose.

REPORT OF SPECIAL COMMITTEE ON CLEARANCES

A. R. WILSON, Iron and Steel Structures (*Chairman*).
C. W. BALDRIDGE, Roadway.
J. V. NEUBERT, Track.
F. R. JUDD, Buildings.
W. E. HAWLEY, Wooden Bridges and Trestles.
C. P. RICHARDSON, Masonry.
F. J. STIMSON, Grade Crossings.
W. M. POST, Signals and Interlocking.
W. C. BARRETT, Rules and Organization.
J. E. ARMSTRONG, Yards and Terminals.
H. M. BASSETT, Electricity.
A. T. HAWK, Shops and Locomotive Terminals.

Committee.

To the American Railway Engineering Association:

Your Special Committee on Clearances submits the following as its annual report for the year 1928:

In order to harmonize the discrepancies now existing in clearance diagrams as appearing in the Manual and Supplements, and to further develop the subject, we recommend that the following Committees have assigned to them for future work the subject:

> Prepare a clearance diagram for recommended practice by which the operation of trains would be affected, with the statement attached as to whether the diagram conforms or conflicts with existing State laws.
>
> Committee I —Roadway.
> Committee V —Track.
> Committee VI —Buildings.
> Committee VII —Wooden Bridges and Trestles.
> Committee VIII—Masonry.
> Committee IX —Grade Crossings.
> Committee X —Signals and Interlocking.
> Committee XIII—Water Service.
> Committee XIV—Yards and Terminals.

We recommend that the Committee be continued.

Respectfully submitted,

THE SPECIAL COMMITTEE ON CLEARANCES,

A. R. WILSON, *Chairman.*

Bulletin 310, October, 1928.

REPORT OF SPECIAL COMMITTEE ON RIVERS AND HARBORS

WM. G. ATWOOD, *Chairman;*
W. J. BACKES,
A. F. BLAESS,
W. G. BROWN,
E. A. HADLEY,
W. E. HAWLEY,
B. HERMAN,
F. G. JONAH,
W. H. KIRKBRIDE, *Vice-Chairman;*
W. L. MORSE,
E. H. ROTH,
W. C. SWARTOUT,
C. E. WEAVER,
C. C. WESTFALL,
W. P. WILTSEE,
R. C. YOUNG,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report covering the subjects assigned as follows:

1. Report on methods for providing against river bank erosion.
2. Determine the best types of construction for levees and river dikes for flood protection giving recommended dimensions.
3. Determine the proper allowance for swell in scow measurement dredge work.
4. Determine the proper amount of allowable overdepth in dredging to obtain the required operating depth.
5. Determine the average deposit in fresh water rivers bearing silt and in brackish waters in the tidal range.
6. Prescribe the best approved method of taking soundings in river waters, in tidal waters, with both hard and soft bottoms.
7. Ascertain the usual slopes taken in deep waterways for quiet waters and those affected by wave action.
8. Determine the effect of slight salinity on deposit of silt in rivers and slips.
9. Study the result of deepening channels on the salinity of rivers and estuaries.
10. Outline of work for the ensuing year.

This being the first year of the work of this Committee, it has been unable to make final recommendations on any of the subjects assigned and therefore submit a progress report only for information.

Recommendations for Future Work

The reassignment of subjects 1 to 9 inclusive is recommended with the following additions:

10. Prepare definitions for terms connected with river and harbor construction, protection and maintenance.
11. Prepare specifications covering the several types of river protection work in common use.
12. Report on the various types of dredges and indicate their respective use.
13. Present specifications for dredging.
14 Outline of work for the ensuing year.

Respectfully submitted,

THE COMMITTEE ON RIVERS AND HARBORS,
WM. G. ATWOOD, *Chairman.*

Bulletin 311, November, 1928.
A

Appendix A

RIVERS

E. A. Hadley, Chairman, Sub-Committee; W. H. Kirkbride, A. F. Blaess, W. G. Brown, B. Herman, F. G. Jonah, W. C. Swartout, C. E. Weaver, C. C. Westfall, W. P. Wiltsee.

Subjects 1, 2, 5, 8, 9 and 10 were assigned to this Sub-Committee. The Committee submits progress report as follows:

Subject 1—Appendix A-1.

Subject 2—Appendix A-B and A-B 1.

Subjects 5, 8 and 9 have been under investigation but sufficient reliable information has not been obtained to make possible a progress report this year.

Appendix A-1

METHODS OF PROTECTING RIVER BANKS AGAINST EROSION

A. F. Blaess, Chairman, Sub-Committee A; F. G. Jonah.

This report is one of progress as the Sub-Committee has not completed its investigation of the subject. Replies are still being received to the questionnaire sent out by the Committee. The information obtained will be tabulated and included in next year's report.

General

Many different methods have been followed in bank protection, depending upon local conditions, such as depth of water, nature and shape of banks, current, character of soil in which erosion occurs, and the amount of silt carried by the stream. The limitations of each type of construction or method must be given due consideration in every case.

In addition to the better known methods of bank protection, such as the use of willow mattresses, riprap, and concrete, many patented devices and schemes have been offered, some of which are of doubtful value and relatively few of practical application.

Brush Mattresses

The "willow mattress" has probably been more extensively used for bank protection than any other form of revetment, the principal reasons for its extensive use being its flexibility which permits it to conform to the shape of the bank and also to the fact that the growth of willows and other brush along the stream usually provides material in a convenient location for the construction of the mattresses. The construction of this type of mattress in the past has been confined chiefly to the larger streams. While many experiments have been conducted in an effort to secure a substitute for the "willow mattress," efforts along this line have not been entirely successful, the development of other forms of mattresses still being more or less in the experimental stage.

Among the various types of "willow mattresses" are: The Missouri River standard basket woven mat; the brush and weaving pole mat; the pole and fascine mat (Fig. 1 and 2), and the brush mat enclosed in a wire envelope. The last mentioned mattress is patented and is made by sewing together 6 inch square mesh netting made of No. 9 wire unwinding the rolls comprising the lower layer parallel with the shore of the stream and sewing the edges of the rolls together with No. 9 wire. Willows are then placed on top of the lower netting, the first layer at right angles to the river bank line and the second layer parallel with the bank, making the thickness about twelve inches. About one-quarter of a yard of stone per one hundred square feet of mattress is then placed on the willow brush. No stone should be larger than what is ordinarily termed one-man stone. Another layer of wire mesh is then placed on top of the stone and brush, the rolls being unwound and sewed together at their edges at right angles to the lower netting. The lower and upper layers of wire mesh are then sewed together with No. 9 wire at intervals of 30 inches each way. The mat is either made on a barge and sunk in the river following the Mississippi River Commission practice in constructing willow brush mattresses or it can be placed on the bank flat, letting it gradually fall into the river as the shore line scours away. On the Missouri River where this type of mat has been used, the ordinary width of the mat is 100 feet. This width will usually sink into the river about 60 feet, leaving 40 feet on the bank (Fig. 3 and 4).

The earlier type of willow mattress used for revetment on the Mississippi River was the light woven willow type, and later a heavy willow fascine type was devised. This latter type of mat is usually built in sheets from 250 to 300 feet wide and about 1,000 feet long. After sinking, the river bank above the mat is graded to a slope of 1 on 3 or 1 on 4 and paved with riprap or sheet concrete (Fig. 5).

Board Mattresses

Plank or board mattresses are sometimes used as substitutes where willow or other suitable brush is not readily available. A mattress constructed of boards or planks is an effective form of protection and will have approximately the same life as a "willow mattress" when used under similar conditions. The principal objection to the board mattress as compared to the "willow mattress" is the difficulty of providing sufficient voids for the retention of the sediment deposited and the ballast required to hold it in position during recurring floods.

Concrete Mattresses

The use of concrete mattresses is still in the experimental stage and very little is known as to their durability or cost. The Mississippi River Commission has been experimenting for a number of years with concrete as a substitute for the sub-aqueous "willow mattress," or mat as it is commonly termed. The first experiments with concrete mats were in

Fig. 1—Weaving a Willow Mattress

Fig. 2—Willow Mattress in Position Before Sinking

the First and Second Mississippi River Commission Districts. These mats were formed of large sheets of concrete about 125 feet long by 50 feet wide and 4 inches thick. The mats were reinforced with wire mesh and steel cables. Later experiments were conducted in the same districts with

Fig. 3—Brush Mattress in Wire Envelope in Graded Slope

Fig. 4—Brush Mattress in Wire Envelope Applied to Caving Bank

concrete mats consisting of slabs 240 feet long by 12 feet wide and 4 in. thick. These mats were reinforced with wire mesh and steel bars. About 1100 feet of bank were protected by mats of this type in 1924. Its further use has been abandoned, however, due to the excessive cost and difficulty of placing the mat. During the year 1926, experiments were conducted in the First and Second Mississippi River Commission Districts* with mats formed of reinforced concrete slabs overlapping and interconnecting. These slabs were 11 feet long, 6 feet wide and 4 inches thick. The slabs overlap and are connected by two ⅝ inch steel cables at intervals of 11 feet. These cables have sliding ring connections at intervals of 6 feet. Cables are also connected to the upper right hand corner of each slab. Developments with this type of mat so far show satisfactory results, and their construction is being continued on a limited scale.

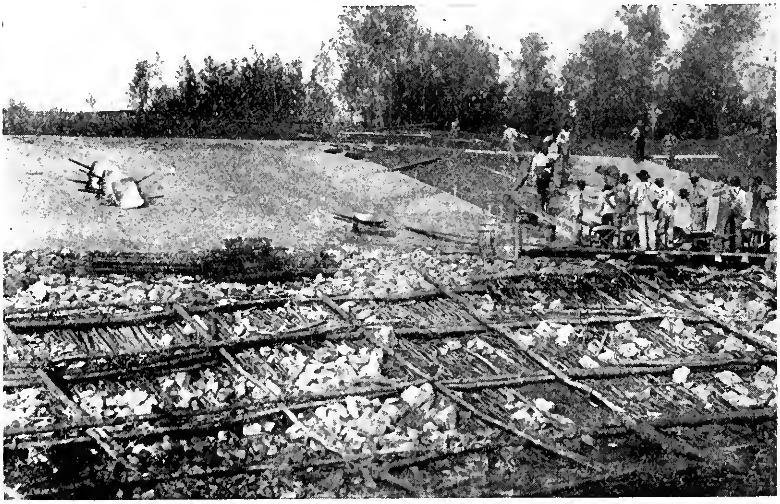


FIG. 5—COMBINATION WILLOW MATTRESS AND CONCRETE REVETMENT

The development of concrete slab protection has also been carried on in the third Mississippi River Commission District. The concrete mats as now built are reinforced slabs 3 feet 11 inches long, 11½ inches wide and three inches thick. These slabs are reinforced and connected by 12 by 12 inch wire mesh of No. 7 steel wire. In building the mats the reinforcing mesh is cut in strips 25 feet long and 48 inches wide, thus forming 25 slabs in each mat unit which is 4 by 25 feet or 100 square feet. The mat units of 25 slabs weigh about 2500 pounds. In placing these mats the ends of the units are fastened together at intervals of 12 inches and are attached to steel cables placed between the units at intervals of 4 feet. The projecting edge of the reinforcing mesh is fastened to the cables at 12 inch intervals.

The construction of concrete mattresses requires a great deal more

*The work of improvement of the Mississippi River under charge of the Mississippi River Commission is divided into five districts, as follows: Northern District—Cape Girardeau to Rock Island, 459 miles; First District—Cape Girardeau to Foot of Island No. 40, 270 miles; Second District—Foot of Island No. 40 to White River, 173 miles; Third District—White River to Warrenton, 218 miles; Fourth District—Warrenton to Head of Passes, 458 miles.

equipment both in manufacture and for placing than either the willow or the board mattress, and they are undoubtedly much more expensive. There would appear to be possibilities in the development of an articulated concrete mat formed of small pre-cast units properly tied together.

Mattresses and Retards in Railroad Work

"Willow mattresses" and retards were used by the Illinois Central System in work carried on jointly by the Railroad and the United States Government in the protection of the Missouri River bank at a point known as The Narrows near Council Bluffs, Iowa. The work was originally installed in about 1892 at the joint expense of the Government and the Illinois Central, the work being done by the Government and repairs made from time to time by the Railroad. There was a length of about 16,000 feet of river bank protected by this work and the destruction of a portion of the mattress in 1921 followed by the cutting of the bank made it necessary to install additional protection in which a patented type of current retard was adopted. The installation was made with a view of protecting approximately 10,000 linear feet of bank, about 3,000 feet of which overlapped the original mattress type of protection (Fig. 6, 7 and 8).

Fig. 6—Shore Protection Missouri River—Illinois Central System—Retard No. 1

A brief description of the current retards adopted for the work at The Narrows and also at the shore pier on the Nebraska side of the railroad bridge over the Missouri River between Council Bluffs and Omaha is as follows: They consist of a dike constructed of full size trees bound together at the trunk end by cables and anchored to the shore at one end and to patented concrete piles sunk in the bed of the river

Fig. 7 Shore Protection Missouri River, Illinois Central System.
Retards 1, 2 and 3

at the outer end and at various intermediate points. The stability and durability of this type of dike is due very largely, if not altogether, to the piles sunk in the bed of the river. These piles are concrete piles which are sunk by water jets below the line of possible scouring, which provides a permanent anchorage because of the fact that much of the structure is entirely below the water surface. These retards have proved quite efficient, the silting of the bank being so rapid that it was impossible to complete some of the retards to their full length, and in one case the silting covered an area so much larger than had been anticipated that one retard which had been planned could not be built.

FIG. 8—SHORE PROTECTION MISSOURI RIVER—ILLINOIS CENTRAL SYSTEM, RETARDS NO. 6-7-8-9-10 AND 14

At the Missouri River Bridge referred to, the channel of the river had scoured to such an extent that 6 feet of piling in the foundation of one pier was exposed at one end of the pier. Three current retards were constructed upstream from this pier, and a bar was formed which satisfactorily covered the foundation of the pier and is still efficient.

The work at both the bridge and The Narrows was done in 1921 at a time when there had been but little previous experience with retards, and there has been some additional work in the nature of restoration of one or two of the retards and protection of the bank where the changing current cut straight into the bank between the retards. With the experience gained from this and other similar installations, locations could probably have been chosen which would have prevented the direct attack upon the bank between the retards. Aside from this fact, however, the retards have proved effective and it is felt that this type of protection is the most satisfactory that could have been chosen for the conditions at The Narrows.

Riprap Protection

Riprap is used extensively in bank protection, particularly on railroad embankments. Ordinarily riprap is used to face the bank from the low water line to a point above the high water line for the purpose of preventing scouring where current prevails, and also for the prevention of wave-wash due to winds. Where stone is not available for riprapping, concrete paving is sometimes used instead.

Sheet Piling

Sheet piling of steel, concrete or timber is used principally in congested areas, as for example around wharves, docks, harbors, etc., where space will not permit of other forms of protection. The cost of sheet piling is usually considerably in excess of other forms of protection.

Spur Dikes

The use of spur dikes is confined very largely to rivers with sand beds. It is extremely difficult to maintain spur dikes on concave banks and therefore their success has been almost altogether on convex banks, where as a general rule a bar is quickly formed below the dike. Dikes may be formed of piling driven below the water line, riprap and heavy stone, brush mats properly anchored to place, or in fact, almost any material that will remain in position and retard the flow of the water to such an extent that a deposit will form below it.

Spur dikes are also constructed of steel and wire entanglements designed to collect silt and drift and form bars. This type has been found very effective on certain heavy silt bearing streams of shallow depth and high velocity. As previously stated spur dikes are seldom effective on the concave side of a bend. When constructed at right angles to the bank they tend to raise the height of the water above the dike which makes it extremely difficult to hold it, and may either result in forming a bar or continued cutting, which would result in making it extremely difficult to hold the dike unless there was a very stable underlying formation. The mud cell brush dike would seem to be more effective as it would act somewhat in the same manner as a retard. Retard anchors could be placed in the river at either concave or convex bank provided they were placed in such a manner that the current could not reach the bank between the retards and the bank. A mud cell dike is similar to a mattress, and sloping the bank and covering it with a willow mattress might be more effective, although it would soon rot and go to pieces unless it were constantly submerged.

Pile dikes vary in type of construction from a continuous row of piling spaced a sufficient distance apart to permit of the water passing through the piles to what is sometimes known as the "hurdle dike," which is constructed by driving alternate clusters of two, three or four piling with horizontal piles tied to the clusters varying distances from the bed or bank of the river. These dikes are designed to permit of the free passage of the water, at the same time retaining drift which causes a bar to form below the dike.

Where it is necessary to hold a permanent bank on the concave side of a bend the value of dikes or retards is open to question, due to the fact that the dike is essentially an instrument for channel deflection or changing, best located at a point remote from the point of attack for the purpose of diverting the channel either as to position or direction.

Erosion Occurrence

The stage at which erosion occurs depends upon the character of the bank. As a general rule the greatest damage occurs principally on a falling river immediately following a flood stage. For example, on some rivers the soil texture is such that the bank will stand almost vertical. Therefore, a softer stratum at the bed is supported to a certain extent by the weight of the water at bankful stage, but as the stage of the river drops this lower stratum has a tendency to scour out, causing the vertical banks to settle, crack off and drop into the stream. This, of course, does not occur where there is a good, firm stratum from the top of the bank to below the bed of the river. Conditions vary to such an extent that no set rule can be laid down.

The finer materials of light specific gravity give the greatest trouble from erosion; clay or gumbo banks are usually the most stable. Irregular formation of the banks, as, for example, a soft or sandy stratum underlying the surface, will often result in erosion of the underlying sand and caving banks. As a rule where the material is of a uniform coarse nature it will form a sloping bank and give less trouble from erosion.

Erosion followed by caving or sloughing of the river bank has occurred at intervals along the river front at Memphis, Helena, Baton Rouge and other points along the Mississippi River, which is apparently caused by underlying strata of fine sand which become thoroughly saturated with water during high stages of the river. The weight of the water against the bank acts as a support until the river falls, when the water flowing back out of the sand stratum, together with the weight of the soil above it, forces the sand out into the channel of the river with the result that the bank settles and caves.

The Memphis River front has been protected from erosion by the river currents from Wolf River to a short distance below the Frisco Railroad bridge by mattresses and dikes constructed during the period from 1884 to 1896. This protection extends to a height of about 30 feet on the Memphis gage below the paved wharf. Above a stage of 30 feet the bluffs rise abruptly, being practically vertical. Between Butler and Calhoun Avenue a subsidence occurred in September, 1917, for a distance of 600 feet with a maximum width of 50 feet. At this locality the bluffs are about 70 feet high and the extensive vertical movement of the large mass of material caused an upheaval of the mattress on the under-water slope for a distance of about 200 feet into the stream, accompanied by considerable scour at its outer end. Another slough occurred in July, 1926, when about 200 feet of the banks sloughed off to a width of 60 feet, while several other smaller sloughs or caves have occurred along the river front from time to time.

Various methods of bank protection have been considered in studying the problem at Memphis, which finally resulted in the favorable consideration of the use of current retards, the effect of which is to cause a deposit of sediment on the bed of the river, which would give protection and stability to the toe of the embankment slope. An important factor in determining upon the use of retards was the fact that this process would not require sacrificing any property such as would be necessary by bank protection necessitating sloping the banks to required grade. While the construction of the proposed retards has not been started, the plan contemplates a series of five retards, having a total length of 1850 linear feet to be located at advantageous points between the mouth of the Wolf River and Georgia Street, the object of the retards being to build the bars in front of the moving bluff, providing support for the toe of the slope and as far as possible preventing water from getting to the underlying sand strata.

In August, 1913, a thousand foot section of one of the heaviest levees on the Mississippi River protecting the City of Helena, Arkansas, sloughed off and slid from 60 to 30 feet toward the river. A second slide occurred during the following month of about the same size, and in October a third cave-in occurred in the adjoining portion of the levee. Trouble had been experienced at this point in former years from sloughing off and caving of the banks. Eleven hundred feet of continuous mattress revetment with stone paving up to the 23 foot stage of the river was built in 1889 and 1899. Four main submerged spur dikes were also built in 1889 and intermediate dikes built about 1898, protecting about 1200 feet of the banks; 2580 feet of continuous revetment built in 1896 and 1898, consisting of fascine mattresses, was constructed below the dike, and stone paving extended to the 25 foot stage and in some places to a higher stage.

At the time the bank caved in 1913 about 3500 feet of the bank was partially protected by continuous revetment, and 1400 feet by submerged spur dikes.

The material above the low water line is blue clay, more or less mixed with sand, usually somewhat coarser near the bottom, and water bearing; quicksand also occurs at some points. This formation rests upon a practically impervious hard clay soil from 35 to 40 feet below the zero stage of the river. The sand stratum out-crops in the river bed from 150 to 250 feet from the zero contour, the mattresses barely covering it in some places. In every case the sloughing off or failure of the levee occurred during periods of low water.

The maximum erosion occurring in twenty-four hours may be fixed at about 100 feet although there have been cases where this has been greatly exceeded. The greatest amount of erosion in a given period in all probability occurs on the Missouri River where it is not at all unusual for 100 feet of erosion to take place in twenty-four hours for several days at a time.

Appendix A-2

CONSTRUCTION OF LEVEES AND RIVER DIKES FOR FLOOD PROTECTION

Sub-Committee A; A. F. Blaess, Chairman, F. G. Jonah.

This report is presented as a progress report with a view of continuing the study. A questionnaire was sent out by the Committee and replies are still being received. The information obtained will be tabulated and included in next year's report.

General

Levees and dikes for flood protection may be roughly divided into five general classes, based upon materials used for construction, namely, earth, masonry, loose rock, and timber, concrete and steel sheet piling. The factors determining the kind of levee or dam to be constructed are: the character of the foundation, space available, height of dam, availability of material and cost. For all practical purposes a discussion of dikes and dams for flood protection may be confined to two classes, namely, earthen levees and concrete walls; rock, timber and steel sheet piling being used very largely for foundation work, for cut-off walls and for the protection of earthen levees and dams from erosion and wash.

A levee properly constructed of earth is a perfectly safe structure. It can be built on a wide variety of foundations, and most important of all it is the cheapest form of construction within certain limits. As a result levees other than of earth are usually constructed only to take care of special conditions where an earth levee would not be suitable. The levee protection of all the great rivers of the world is constructed almost altogether of earth. For example, the Mississippi River and its principal tributaries have more than 1800 miles of main levees, practically all of which are of earth. Therefore, a discussion of types of levees and dikes is necessarily confined very largely to earth embankments.

Design of Earth Levees

It has been said that no mathematical formulæ or even general rules can be laid down for the design of earthen levees or dams. While this statement is true to a certain extent, at the same time certain methods of construction have been established through experience, and in some cases it has been possible to arrive at approximate dimensions under certain conditions. More important than dimension or design is the careful selection of material and care in construction.

Earthen embankments or levees may be divided into five general classes: (1) Simple embankment built up in layers of homogeneous material without core; (2) Levees with a central core or wall of puddled earth or masonry; (3) Levees with a central core of steel, concrete or timber sheet piling; (4) Levees built by hydraulic fill; (5) Levees with puddle or masonry facing.

No hard-and-fast rule may be laid down for type of levee construction as the type of construction will be governed to a large extent by local conditions, the principal factors involved being the amount of space available for the levee and the comparative cost of materials. Other factors are the character of material available at the site, foundation conditions and topography.

The function of an earth levee, as well as any other type, is to prevent the passage of water. Therefore, a heavy, tenacious natural impervious earth is the most desirable. In the classification of material, hardpan, natural glacial drift and till are among the most desirable; some mixtures of sand, gravel and clay also make an excellent embankment.

Foundations

While there is but little information available in regard to foundations for earth levees the foundation and its preparation are important factors affecting their stability. The character of the material forming the foundation will determine to a very large extent the slopes of the levee, as while definite slopes may be established for certain heights, poor foundation conditions may necessitate increasing them. A poor foundation may be due to a porous material which will permit seepage, or unstable material which will not support the weight of the levee. Seepage through the foundation may be overcome by the construction of muck ditches, puddle walls or the use of sheet piling. It is always advisable to construct an exploratory muck ditch where the character of the material is not fully known. Where the foundation material is unstable there is usually no other recourse than to widen the base of the levee to obtain proper distribution of the load.

Vegetation and top soil should be removed from the area to be covered by earth levees. If the foundation material is not firm it should be compacted by rolling or other means. Tree roots should be grubbed out and all vegetation and pervious material removed and every precaution taken to prevent seepage beneath the embankment.

The Mississippi River Commission removes all stumps and roots down to 4 inches in diameter from levee foundations. In addition to the above precautions the foundation is sometimes furrowed or stepped as an additional precaution against seepage beneath the levee. This is particularly necessary where the foundation is shale or rock, or where the levee is located on a slope, as extreme precaution is necessary to prevent the levee sliding on its base.

Character of Material

The character of material used and the method of construction are of almost equal importance, as both are essential to a satisfactory structure. If the material available is inferior more care will have to be exercised in the construction. If a suitable material is not available in its natural form it is possible that the desired stability may be secured by artificial mixtures. An embankment constructed of porous material will make as safe an embankment as one of impervious material provided it is properly constructed. Where the material is not suitable it may be necessary to increase the cross section of the embankment or in some cases the difficulty may be overcome by the construction of a core-wall and in others by facing the embankment with impervious material.

The poorest material for an earth embankment is sand or gravel on account of the porosity of the material; however, embankments have been formed of sand, loam and gravel by grading the material in such a manner that the coarser particles would form the lower part of the embankment which would act in the same manner as a filter bed, the coarser particles preventing the finer particles washing. A bank of this kind will eventually become impervious to water where the water contains silt or mud. It is, of course, necessary that such embankments be constructed only of moderate height. A poor clay is objectionable for the reason that it will hold the water and tend to slough off. It is also subject to erosion unless faced with loam which will permit of producing a sod to prevent wash.

It is sometimes practicable to construct a safe levee with poor material by placing a core-wall of concrete, puddle or sheet piling. It is also sometimes advisable to puddle the river face and protect the land face with sod or riprap. The Mississippi River Commission provides an additional embankment termed a banquette on the land side of the levee so that the line of saturation will enter the ground under the levee. The theory is that when a levee with a 3 to 1 slope reaches a certain height the line of saturation slopes down from the water line at an angle of 12 degrees and unless a banquette is provided the water will pass out of the land slope above the ground line and may cause the failure of the embankment.

Core-walls

Impervious core-walls are practical and are used quite extensively. There is a question, however, whether the same result could not be secured by flattening the slopes and increasing the width of levee base. Core-walls are used chiefly in dams of impounding reservoirs. A puddle core is the cheapest and is effective when properly constructed. Puddle core-walls should be constructed of carefully selected materials. The minimum thickness of wall is usually accepted as 4 feet and should start in trenches excavated to impervious earth. They should be carried at least to the line of saturation and preferably to the water level. With high embankments it is even advisable to carry them from 2 to 4 feet above the water level. Clay, sand and gravel form an excellent mixture for the construction of puddle cores; no stone should be permitted in the core larger than 2 inches. In some cases carbonate of soda has been used in the construction of core-walls. It is claimed that 1 per cent carbonate of soda will make almost any earth available for puddling. A concrete core-wall may be made much thinner than a puddle wall, although the same method should be followed in excavating to impervious earth, and the wall should be carried at least to the line of saturation. Where a core-wall is used it really forms the levee, the earth merely being a protection to the wall itself. Pavement on the water face of the levee is sometimes constructed as a substitute for a core-wall. It is usually more expensive, however, and is subject to cracking and damage by ice, waves or extreme summer heat. Rapid fall of the water may cause a back pressure behind the paving unless drains are provided.

Placing Material

The method followed in handling the material from pit to levee will be determined very largely by the comparative cost of various methods. The important feature in placing material is that it should be deposited in uniform layers the full width of the levee. The thickness of these layers should not exceed 2 feet, depending upon the kind of material, the amount of moisture and method of compacting. If wheel scrapers or

Fig. 9—Bottom Dump Wagons Building Levee

dump wagons (Fig. 9) are used in transporting the material, rollers will not be required for compacting; where the material is handled by drag line buckets, it should be thoroughly compacted by rolling. The material should be moistened just enough to permit of its being properly compacted. An excess of water, where the layers are rolled, may make the rolling more difficult and increase the amount of settlement. The work of compacting the successive layers is of importance and should be strictly followed.

Hydraulic Fill

Hydraulic fill dams and levees have been used very successfully in many instances (Fig. 10). This is particularly true of the Western part of the country. The idea of constructing dams of hydraulic fill probably originated in the days of hydraulic mining in California.

When properly carried out the entire hydraulic process, including excavating, transporting, sorting and depositing material, is done with water. This method of constructing levees is not confined to any particular class of material. The most suitable mixture is one composed of loam, clay, sand and gravel. Rounded boulders can be used in this form of fill up to any size that may be transported by the water. A notable example of hydraulic earth fill is in dams constructed by the Miami Conservancy District of Ohio. This method of construction requires extreme care both in sorting and mixing the materials used as well as the prevention of pervious stratification in the dam. The proper slope of hydraulic fill levees and dams is maintained by even distribution of material along the slopes. Sand and gravel with sufficient clay to form a lubricant will deposit at a slope of about 1 to 1 in a quiet pool and will take a natural slope of from 5 to 10 per cent.

Fig. 10—Hydraulic Fill Showing Angle of Slope

Dimension of Levees

The width of crown, cross section and slope of levee are dependent upon the character of material, height of levee and foundation. With a crown of a definite width and proper slopes it is obvious that the balance is taken care of. The height of the existing levees on the Mississippi River Levee System varies with the ground upon which they are located as compared to the high water plane of the river, the average being about 15 feet. The crown of existing levees is 8 feet in width except for levees above the mouth of the Missouri River where the crown width is reduced to 6 feet. Both river and land side slopes from the levee crown are 3 to 1.

Standard levees above 10 feet in height are provided with a banquette on the land side. This banquette is 20 feet wide for levees 10 to 13 feet high and 30 feet wide for levees 13 to 16 feet high, and 40 feet wide for levees exceeding 16 feet in height. The crown slope of the banquette is 10 to 1 and land side slopes from the banquette vary from 4 to 1 to 5 to 1, the existing standard being 4 to 1. The grade line of standard levees is assumed to be 3 feet above ultimate high water in the river (Fig. 11).

The existing levees were designed with the idea of keeping within the safe limits of percolation or seepage and at the same time maintaining a cross section that would require the minimum amount of material.

Settlement

Complete settlement of earth levees does not occur for a number of years after construction. The amount of settlement that may occur will be governed almost entirely by the manner in which the material is placed. There are instances where earthen dams 50 feet in height have settled less than 1 per cent, due to the material having been thoroughly compacted as placed. As a rule it is well to figure on a settlement of 10 per cent.

Protection from Erosion

Ordinary wave-wash and erosion can be overcome by sodding the slopes of the levee, and in extreme cases or at points where the worst washing occurs, placing riprip, concrete paving or timber revetment. The best grass for sodding slopes is one with strong roots that will form a heavy sod.

Protection from Burrowing Animals

There are at least a dozen different animals that are liable to injure earth levees by burrowing, among which are porcupines, badgers, foxes, skunks, beavers, woodchucks, muskrats, moles, rats, mice and rabbits. These last five animals offer the most serious problem in this country, as the first mentioned are becoming more rare and therefore there is less danger from their burrowing.

The muskrat is undoubtedly the most dangerous animal to be considered in this connection, as it has given more trouble than any other in embankments. Crawfish, turtles, snakes, eels and worms are also liable to cause trouble with earth embankments.

Various methods are followed in protecting earth embankments against the inroads of these animals. Perhaps the most effective is the construction of these embankments with firmly packed, hard-rolled homogeneous material. This is not possible in every case as the proper material is not always available and it adds considerably to the expense. Paving one or both slopes with concrete is also an excellent method of preventing animals from burrowing into the bank. This, while effective, is a very expensive form of protection.

Core-walls are also effective when constructed of concrete or timber. Where the core-wall is constructed of wooden sheet piling the timber should be creosoted, as in addition to adding to the life of the timber the creosote is repellent to most animals. A puddled core-wall is useful if constructed of the proper material. A puddle wall should be composed of 75 to 80 per cent of gravel, as the gravel offers more resistance to the

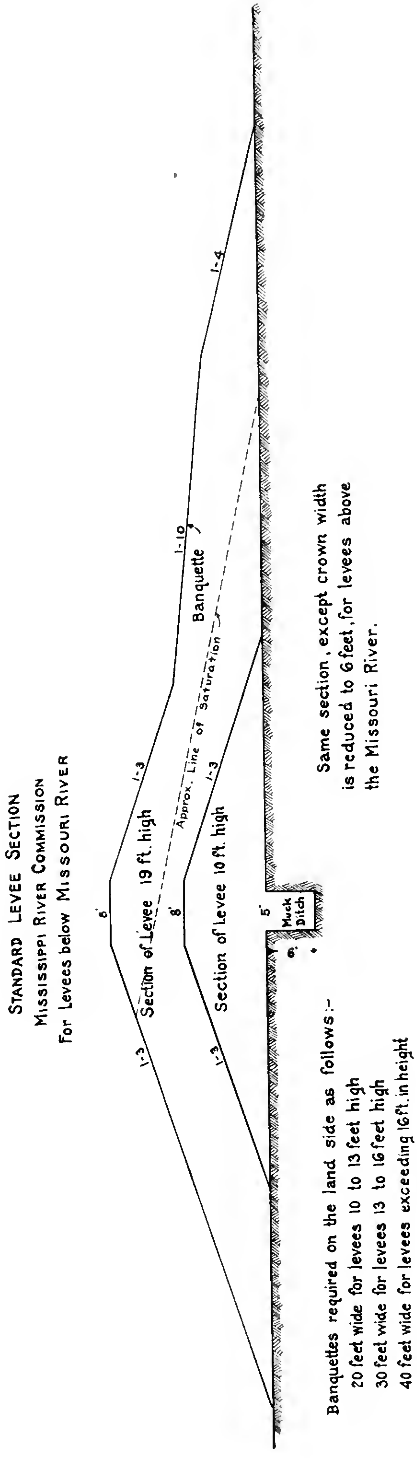

Standard Levee Section
Mississippi River Commission
For Levees below Missouri River
8'
Section of Levee 19 ft. high
1-3
1-3
1-10
Banquette
1-4
Approx. Line of Saturation
8'
Section of Levee 10 ft. high
1-3
1-3
5'
Muck Ditch
6'
Same section, except crown width
is reduced to 6 feet, for levees above
the Missouri River.
Banquettes required on the land side as follows:-
20 feet wide for levees 10 to 13 feet high
30 feet wide for levees 13 to 16 feet high
40 feet wide for levees exceeding 16 ft. in height

Fig. 11

animals than clay or earth. One of the simplest and least expensive methods of protecting the embankment is sodding the land slopes, and while it is not as effective as paving the slopes or constructing a core-wall it offers resistance to burrowing animals in most parts of the country. If the possibility of damage from burrowing animals is very great the embankment should be provided with a core-wall extending from below the foundation line to a point above the water line. Paving the river slope and sodding the land slope of the embankment offers as good protection from animals as a core wall and while more expensive has the added advantage that the paving on the river slope and sodding on the land slope prevents damage from wave-wash on the river side and erosion on the land side.

Appendix B

HARBORS

W. L. Morse, Chairman, Sub-Committee; W. J. Backes, W. E. Hawley, E. H. Roth, R. C. Young.

Subjects No. 3, 4, 6 and 7 were assigned to this Committee.

To a questionnaire seeking information as to experience relating to the assigned subjects and sent to various railroads, members of the American Railway Association, fifty-one railroads replied. Twenty-seven of these railroads were without experience and could furnish no information, while twenty-four furnished information based upon experience. In addition, information was received from Washington, Boston, New York and Duluth offices of the United States Engineers, War Department; from the Navy Department at Washington and also from the Department of Public Works, Commonwealth of Massachusetts.

Based upon the replies received, the Committee submits for consideration its report as follows:

(3) Allowance for Swell in Scow Measurement Dredge Work:

The character of material to be dredged determines the scow factor to be used. Ratios vary not only for material but according to locality and method used in dredging.

Payment for excavation by dredging is usually made by one of two methods, namely, place measurement and scow measurement.

In maintenance it is customary to pay on the basis of cost plus an agreed profit.

For new construction or original dredging the following is suggested:

(1) Where possible, payment should be made on actual measurements obtained by soundings before and after dredging.

(2) Where local conditions do not favor payment by actual measurements, payment should be made by scow measurements with no allowance for swell.

(3) Where it may be necessary or desirable to allow and pay for swell, local conditions must prevail.

A fair allowance may be:

Hardpan and sand, 0 per cent to 5 per cent.
Sand and gravel, 5 per cent to 10 per cent.
Clay and hardpan, 10 per cent to 20 per cent.
Ledge, clay or stiff mud, a maximum of 30 per cent.

(4) Allowable over-depth in dredging operations to obtain the desired operating depth:

The allowable over-depth depends upon the character of the material and the depth of channel required. This must be governed by the type of plant used, the silting of streams and the desirability and economy of doing maintenance dredging at long intervals.

Over-depth of channel is allowed to assure a continuous channel depth and as a protection against shoaling above the desired channel depth from any natural conditions.

The usual over-depths for the channel, that is, the depth below the desired channel depth to which the channel should be dredged, are:

For channels in sand or soft materials, less than 24 feet in depth, 1 foot is allowed.
For channels in sand or soft materials, in excess of 24 feet, 2 feet are allowed.
For channels in hard materials with no chance of natural shoaling, 1 foot is allowed.

(6) Usual slopes taken in deep waterways:

The determination of side slopes actually assumed by different materials can be obtained only by observation. Current, depth of water, wave action and presence of cross-currents, as well as different classes of material, determine the slopes. It is usual to base estimates on a 1 on 3 slope. Some material such as clay and hardpan will stand on a 1 on 2 slope, while sand will assume a flat slope, at least 1 on 5.

(7) Sounding methods in river and tidal waters:

In climates where ice forms in winter the best method of taking soundings is through the ice through holes bored by a machine especially designed for the purpose. In this method the soundings are accurately located and the work can be covered again with soundings taken in the same locations so that comparison can be made without interpolation or other adjustments other than those due to change in water level or error in sounding line.

The apparatus used is mounted on a frame which may be fastened to a boat or sled as desired. It consists of a reel whose circumference measures ten feet with graduations in feet and tenths of a foot on one side. Attached to the shaft through the center of the wheel is a crank by which the operator turns the wheel as desired. There is a small dial which indicates the number of full revolutions made and a radial arm which may be set at any given position and will remain in that place regardless of the motion of the wheel. The operation of the reel is as follows:

> A water gage is read to give the elevation of the water surface.
>
> The lead is lowered to the surface of the water. With the lead in this position the radial arm is set at 0.0 of the graduation on the wheel.
>
> The lead is then lowered to the bottom and the depth read from the two dials.
>
> The only correction to the reading is that due to the water gage reading.

Where ice is not available and the ordinary survey methods cannot be used, the following methods may be used for locating soundings:

(1) A range, with transit cutoffs to locate soundings.
(2) A range, the soundings being located by a measuring line or tape. This method can be used with good results in channels 500 feet wide but not so well in greater widths.
(3) A range, soundings being taken at regular intervals of time between certain cross ranges or between soundings located by transits.
(4) Soundings located by two transit intersections or by one transit sight and sextant operated from a boat.

Boats are used in making soundings as enumerated under the above four items. Under item (3) the boat moves at a uniform rate on cross ranges laid out in a fan shape from a pivot point, or in parallel. The man taking the soundings stands in the bow of the boat and takes, usually, six soundings to the minute. The transitman, located at a favorable triangulation station, cuts in at half minute intervals on the position of the sounding man. This is accomplished in the following manner:

> The recorder in the boat has his watch set to agree with the transitman's watch and at the half minute intervals he calls out to the sounding man to raise his free hand so that the instrument man can turn an angle to it.
>
> Tide gages must be set up before soundings are taken and a comparison of the readings made at the same time soundings and instrument notes are taken so as to determine the corrections.

In taking soundings, poles, chain tapes, Engineers' link chain, a link chain so constructed that each link is a tenth of a foot and marked each foot by leather tags, a water-proof solid braided rope with a phosphor bronze stranded wire center, or plain wires with heavy lead are used in rivers with hard bottoms.

In soft bottoms a wire with a perforated weighted disc or a lead with a piece of board about six inches square nailed to its bottom is used.

In hard bottoms, any weighted lead can be used, depending upon the current.

In slack water or in light current, a three-and-a-half pound lead will answer.

If the current is strong and the water over twenty feet deep, it will be necessary to use a 12 or 14 lb. lead.

There is practically no difference between harbor and river work except that there are occasions in harbor work where two sextants may be used from the boat instead of using transits on shore. This method allows the man in charge of the party to be in the boat and to detect at once if the boat is off range. When soundings are at a considerable distance from the shore, buoys are set on the range line where they can be used with shore points to make the sounding range definite.

Conclusions

It is recommended that the report covering the work of Committee "B" be accepted as a report of progress and the work continued in connection with the following subjects.

1. Prepare definitions for terms connected with harbor work.
2. Work up general information relative to types of dredges and their respective uses.
3. Specifications for dredging.

Appendix A-3

PROTECTION AND MAINTENANCE OF LEVEES DURING FLOOD

A. F. Blaess, Chairman, Sub-Committee; F. G. Jonah.

This appendix to the report on levees covers suggested methods of levee protection work during floods, and together with Plates 1, 2, 3 and 4 is taken from instructions to levee engineers, inspectors and supervisors, prepared by H. N. Pharr, Chief Engineer, St. Francis Levee District of Arkansas.

Caving

In case of a caving on river side slope of levee, drive board piling two inches thick close together with a slope inward and upward. Anchor with horizontal members from top of piling to land side crown of levee. If caused by a strong current along levee, throw out a dike of sacks filled with buckshot near point of caving and throw current off threatened point. It may be necessary to tie 4 or 5 sacks together well with rope, or wire cable, and roll into current, then anchor cable to crown of levee. This latter remedy may suffice by applying at immediate point of caving without use of piling.

The treatment of a swift current along the levee to prevent scour of the levee slope or borrow pit and a consequent undermining of the levee requires the careful location of a spur dike or abatis works in order that the conditions and danger may not be made worse. The object is to decrease the velocity of the current at the point of attack and by no means increase it or shift it to another point along the levee that will be undesirable. Generally dikes and abatis works should be constructed at right angles to the down-stream tangent of the levee. They should extend out into the stream far enough to prevent the re-entrance

PLATE 1

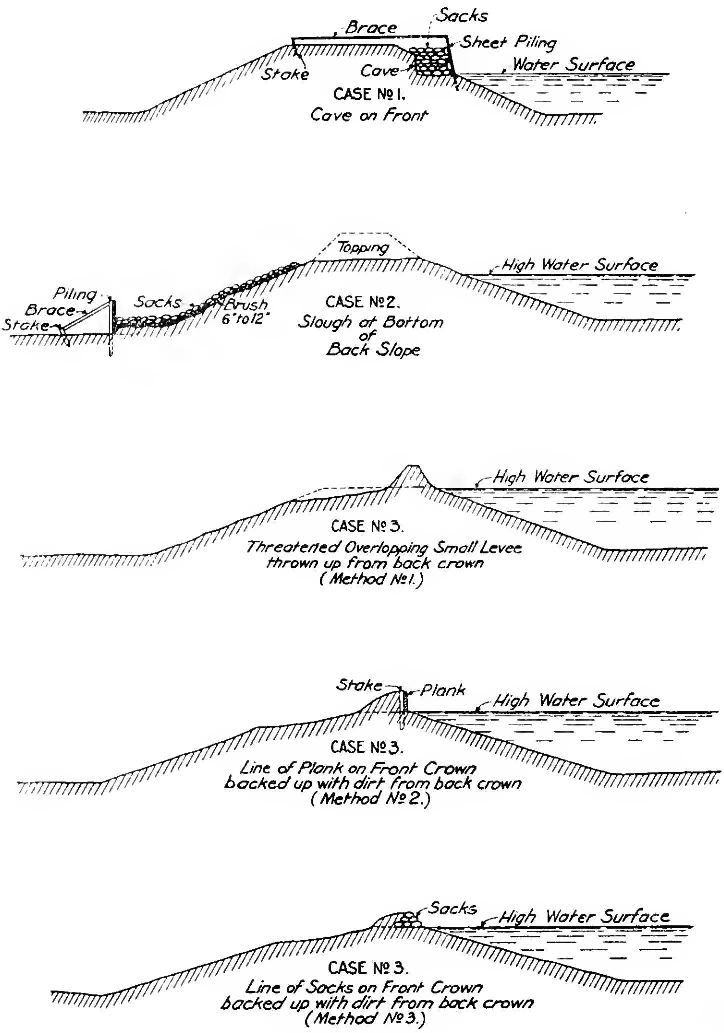

Sacks
Brace
Sheet Piling
Water Surface
Stake
Cave
CASE No 1.
Cave on Front
Topping
High Water Surface
Piling
Brace
Stake
Sacks
Brush 6" to 12"
CASE No 2.
Slough at Bottom of Back Slope
High Water Surface
CASE No 3.
Threatened Overlopping Small Levee thrown up from back crown (Method No 1.)
Stake
Plank
High Water Surface
CASE No 3.
Line of Plank on Front Crown backed up with dirt from back crown (Method No 2.)
Sacks
High Water Surface
CASE No 3.
Line of Sacks on Front Crown backed up with dirt from back crown (Method No 3.)

PLATE 2

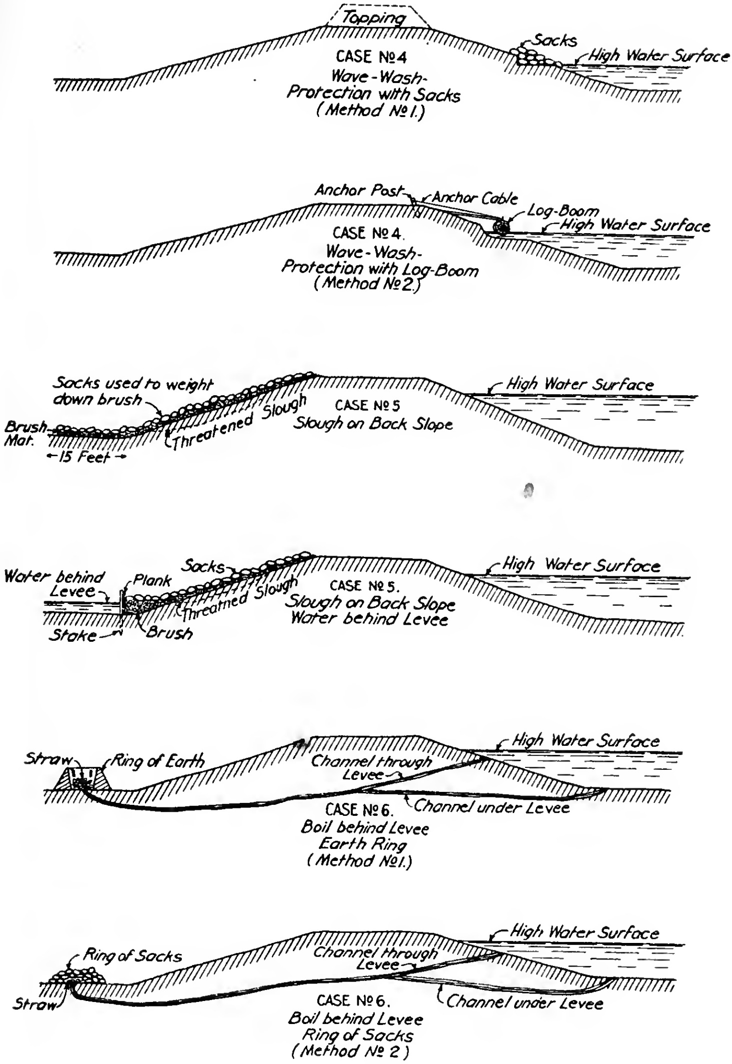
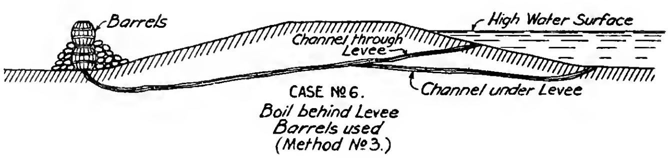
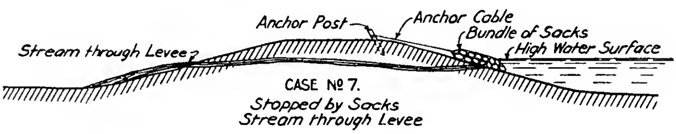
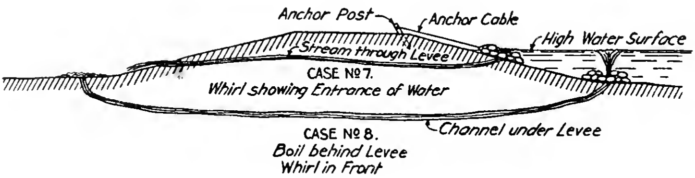

Topping
Sacks
High Water Surface
CASE No 4
Wave-Wash-
Protection with Sacks
(Method No 1.)
Anchor Post
Anchor Cable
Log-Boom
High Water Surface
CASE No 4.
Wave-Wash-
Protection with Log-Boom
(Method No 2.)
Sacks used to weight
down brush
Brush
Mat.
← 15 Feet →
Threatened Slough
CASE No 5
Slough on Back Slope
High Water Surface
Water behind
Levee
Plank
Sacks
Stake
Brush
Threatened Slough
CASE No 5.
Slough on Back Slope
Water behind Levee
High Water Surface
Straw
Ring of Earth
Channel through
Levee
High Water Surface
Channel under Levee
CASE No 6.
Boil behind Levee
Earth Ring
(Method No 1.)
Ring of Sacks
Straw
Channel through
Levee
High Water Surface
Channel under Levee
CASE No 6.
Boil behind Levee
Ring of Sacks
(Method No 2)

PLATE 3


Barrels
High Water Surface
Channel through Levee
Channel under Levee
CASE Nº 6.
Boil behind Levee
Barrels used
(Method Nº 3.)


Anchor Post
Anchor Cable
Bundle of Sacks
High Water Surface
Stream through Levee
CASE Nº 7.
Stopped by Sacks
Stream through Levee


Anchor Post
Anchor Cable
High Water Surface
Stream through Levee
CASE Nº 7.
Whirl showing Entrance of Water
Channel under Levee
CASE Nº 8.
Boil behind Levee
Whirl in Front

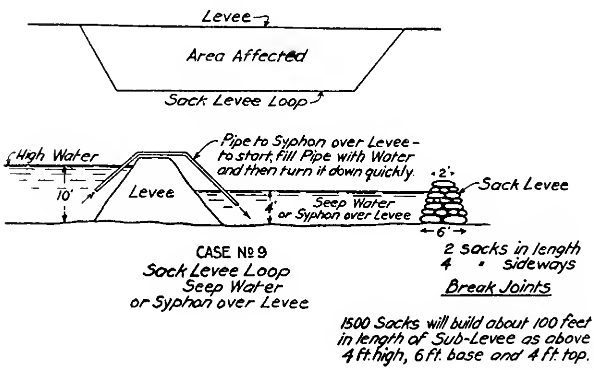
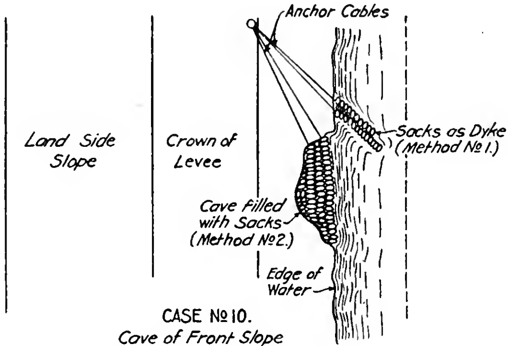
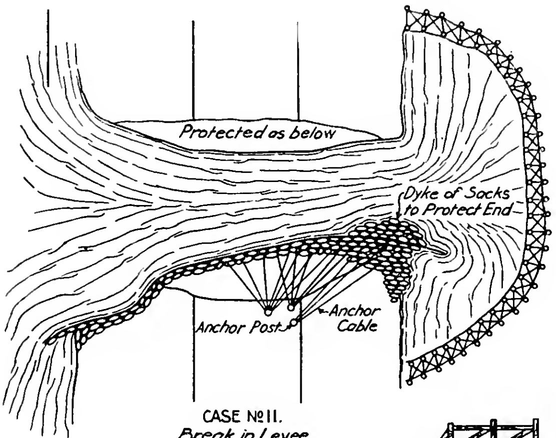

Levee
Area Affected
Sack Levee Loop
High Water
Pipe to Syphon over Levee - to start, fill Pipe with Water and then turn it down quickly.
10'
Levee
Seep Water or Syphon over Levee
4'
2'
Sack Levee
6'
CASE Nº 9
Sack Levee Loop
Seep Water
or Syphon over Levee
2 sacks in length
4 " sideways
Break Joints
1500 Sacks will build about 100 feet in length of Sub-Levee as above 4 ft. high, 6 ft. base and 4 ft. top.

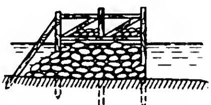
PLATE 4



CASE No 10.
Cave of Front Slope
Caused by Strong Current



CASE No 11.
Break in Levee
Method of Closing



End Elevation
Three Rows of Piles

of the swift current to the levee. A dike might be constructed above the point of attack and at an acute angle with the down-stream tangent so as to increase the velocity and at the same time throw the current against the slope of the levee and this should be studied and avoided. Usually the dike should not be located above the point of attack and generally it is preferable to locate it below the point of attack—but not so far (particularly in the case of an abrupt angle in the levee) as to lose the effect of the dike in impounding the water, decreasing the slope and velocity above, and directing the current away from the levee. A dike or dikes properly located should distribute the slope and velocity of the water along the levee in such a manner as to reduce it beyond scouring energy.

Should the caving bank of the river threaten to breach the levee, the caving may be checked by the use of cotton bagging sewed together in desirable widths and thicknesses and woven to wire mesh (1 inch mesh chicken wire) of suitable strength to give transverse stability to the bagging when placed to protect the bank against the velocity and impact of the water and flexible enough to conform to the face of the caving bank. Cross-bars of ½-inch steel may be placed about every ten feet and at the top to act as spreaders. The bagging so reinforced should be wired to and wound around a heavy iron pipe of six or more inches in diameter and ten feet or more in length and then launched over the caving bank into the river. The top of the bagging should first be anchored by ropes, wire or cable well back from the bank. The length of the bagging when so launched should be sufficient to allow the iron pipe to sink below the strata of sand that is being attacked and scoured by the current and causing the caving of the bank. This length may be forty feet or more. Intermediate lengths in shingle fashion may be launched to hold and weight the under bagging. If necessary, additional weight may be given the iron pipe by filling same with concrete or stone but otherwise the pipe should be left open so as not to create any buoyancy by inclosing the air. The same method may be used to protect the slope of the levee against caving or wave wash from storms during floods, though in this case the bagging in double width and thickness if desirable may be placed lengthwise with the levee over the area attacked and weighted down with sand bags and anchored with stobs to the levee. Hay or grass may in some cases be placed under the bagging to advantage. An effective dike or abatis may be constructed quickly and economically by using felled trees where available and floating same into place with the butts of the trees anchored to the bank or levee by ropes or cables and the branches extending out and down into the current. Each succeeding tree so placed will tend to cause a jam creating compactness and weight for submergence. Piling driven in a double row as a dike and filled in between with willows and brush and weighted down well with stone or sacks of earth is an effective method of throwing the current away from the levee and preventing its damage by scour.

Sloughs

To treat a small slough on the side of the levee, place a compact revetment of cane over the soft part with the butts toward the base of the levee, the tops toward the top of the levee. Begin by placing the first layer of brush with the butts well out on the land side berm of the levee, several feet outside of the levee base, from five to fifteen feet, according to the magnitude of the slough; lay a second course on top of the first, the butts of the second lapping well over the tops of the first. Continue the courses of brush in the same manner as boards on a roof, up the slope of the levee until the soft part is completely covered and the revetment extends well up to firm ground above the weak part, also extending up-stream and down-stream beyond the limits of the soft part. The brush or cane should be a thick and compact carpeting on the soft ground, six inches to a foot thick, so as to prevent the dirt or sacks of earth when placed upon it from becoming saturated with water from beneath. The revetment should then be covered with a mass of loose dirt, if convenient, otherwise sacks must be used. The loose dirt, if in sufficient quantities, will do as well as sacks and is much cheaper. The effectiveness of this treatment depends upon bonding together a wide surface of the levee, and the weak part with the firm ground below and above it.

In case of large slough on land side slope of levee, drive piling near foot of slope and brace with piling and horizontals on land side berm of levee; place boards longitudinally with levee, nailed to piling to support the weight of the sliding earth; place brush lengthwise from berm near base of slope to crown to afford a sub-drainage, and beginning at berm near base of slope, weight brush down with sacks filled with earth, decreasing the amount of sacks used as top of levee is approached. Great care must be taken that sacks of earth are not thrown indiscriminately on sliding portion. Unless properly braced and necessary under-drainage given, this increased weight of sacks of earth will only tend to increase the sloughing.

If there is a low place and deep water on the land side of the levee, drive a row of stout stakes three or four feet from the slope of the levee or banquette, brace them well and pile a compact mass of brush between the stakes and the slope. Weight the brush with sacks of dirt.

When brush or cane for revetting purposes is not to be had, fence rails or planks may be used. To use rails for this purpose, first place a layer on the berm with their heads abutting against the toe of the slope two rails deep; then a similar layer up the slope with the bottom ends resting on the first layer; then a third course above the second, etc. Place a mass of loose dirt in blanket fashion over the rails, or planks, if used.

In any kind of revetment on a sloughing levee, the true principle is not to dam the water and force it upwards through the revetment, but to allow it to flow off through or under the brush. The brush, rails or planks, will prevent the dirt from going with it, and when a wide surface is thus bonded together and to firm ground below and above, seep water may flow freely without endangering the levee.

Topping

In case of threatened overtopping of levee, a small levee may be constructed with shovels where crown is of sufficient width and placed near front or river side of crown of levee, the dirt obtained from banquette or back crown of levee, if necessary. No dirt must be taken from land side slope, and sod must be left intact. It will be best, if time permits, to obtain the earth for topping from the banquette or the land side berm and convey it with wheelbarrows. Teams climbing the land side slope of a saturated levee will be likely to bog, increase the seepage and endanger the levee. The above will answer in localities not exposed to the wind or wave wash. In exposed localities it will be found necessary to protect the small top levee by driving small piling near river side edge of crown, just in front of small levee, and nailing boards longitudinally with levee to piling or place sacks filled with buckshot or the best dirt to be obtained, on front of crown, and back with earth as above. In robbing the rear of the levee to get dirt for topping, do not dig holes to catch the seep water and hold it, but take, say, two feet, or more if necessary, off the rear part of the crown or banquette, and slope it back down the rear slope of the levee, so as to promote drainage. The land side slope of the levee and the banquette should be kept as dry as possible by numerous very small V shaped drainage ditches.

Sacks may be used, of course, for topping, and generally are especially used where the crown of the levee is narrow and when the dirt is obtained outside of the levee itself, but they are very expensive and if the levee has to be robbed, the combination of planks and dirt will do as well in localities not exposed to wave wash and is both cheaper and more expeditious. If planks are not at hand, poles or fence rails may be used. When leakage takes place through or under the topping, loose dirt should be poured into the water on the river side, and the leakage will be quickly stopped.

Wave Wash

In case of excessive wave wash on river side slope of levee, fill sacks and place them to catch the force of the wave. All sacks should be well filled with earth and then the mouth of the sack sewn up with twine. It may be best and cheaper to cut logs of timber about one foot in diameter, fasten ends together with chain, or otherwise, and drop down as a boom in front of wave-washed portion. Anchor boom well to levee and at a little distance in front, in best position to break the crest of the wave. Owing to the disposition of the logs to ride the waves this method of protection is not entirely effective. To protect the slope of the levee against severe wave wash where a horizontal bench has been washed into the slope of the levee drive 2 x 6 inch lumber spaced a few feet apart and placed on edge, into the bench or slope of the levee just below the surface of the water and slanting towards the top of the levee at an angle of about 45 degrees with the vertical, brace same with horizontal lumber to piling driven in the crown or land side slope of the levee and wall with boards at proper elevation to receive the impact of the wave. It may be found preferable to construct a breakwater of this character in sections and afterwards launch and drive same in place. If the placing of such breakwater is considered desirable as a precautionary measure before the wave-wash has caused damage the wall may conform more closely to and be supported more fully by the natural and undamaged slope of the levee and anchored with piling. Wire and cables, owing to their lack of rigidity, do not afford good anchorage or supports for these breakwaters.

Boils

A boil near the base of the levee or out on the berm may be treated by simply placing a compact cushion of brush on it and weighting it down with sacks or loose earth not to suppress the flow of water altogether, but to allow it to trickle through the brush without carrying out any earth with it. So long as the earth remains behind, the flow of clear water does not harm.

If the volume of water is so great as to create alarm and cannot be safely treated as above described, then a pond or pool should be made over the boil or stream, either by a hoop levee of loose earth or a well of sacks filled with earth. If sacks are used, some loose hay placed around the inside of the well will prevent leakage between and under the sacks. If loose earth is used, an opening must be left for the water to flow out until the remainder of the hoop is tight enough, when the outlet must be rapidly closed. A gutter of plank or sacks filled with earth must be provided to allow the water to waste over the hoop without washing away the loose earth.

Where there are numerous small boils of medium magnitude it may be effective to place a watertight wooden barrel, with the head and bottom removed, over each boil and weight the barrel with sand bags or other material in such a way as to hold same in place and well to the ground so as to allow the water flowing from the boil to rise in the barrel. If the boils are numerous and of large magnitude it will be found more expeditious to encircle the entire area with a sub-levee of sufficient elevation to impound the water over the boils to a depth that will in an effective manner tend toward equalizing the water pressure from the river side of the levee. A spillway for the sub-levee must be carefully provided. Similar measures may be adopted where the levee crosses bayous, old rivers or depressions that develop foundation weakness.

It should be borne in mind that sand boils eminating from a sub-levee may flow clear water instead of muddy river water and may be more active and dangerous than apparent from a cursory examination.

If a bold spring appears on the land side near the base or on the slope of the levee, increasing in volume and carrying material with it, indicating a dangerous and critical condition, lose no time in rushing earth or sacks of earth into the water on the river side of the levee, opposite the point of outflow. In a similar manner a blanket of loose earth placed over the river side surface of slope of levee will tend to decrease seepage through levee.

If a whirl indicating a strong suction is seen on the surface of the water on the river side, pile sacks filled with earth as rapidly as possible into the water beneath the whirl. If the whirl is too far out to reach readily, pile the sacks outward from the levee until the vital point is reached and covered. Time is of the utmost importance in this operation, but breaks have frequently been prevented in the above manner, when the case seemed hopeless. Certain coloring matters may be used to assist in locating the position of the suction and determining its force and direction.

Crevasses

In case of a break in levee, revet ends and throw out dikes to throw current off of exposed ends. Sacks thrown in singly in this instance will probably do little good. Tie several sacks together and roll in place where wanted, controlling the settling of same by rope, with which anchor sacks to levee. When a break is checked from widening make an attempt to close break by driving piling, in a convex direction, to river side of levee. Brace well and use brush and sacks filled with buckshot to fill between piling. Back up with sacks.

All material received by each engineer, inspector, supervisor or foreman will be receipted for and branded and carefully collected, invoiced and stored in warehouses when the water has subsided.

REPORT OF COMMITTEE III—TIES

W. J. BURTON, *Chairman;*
JOHN FOLEY, *Vice-Chairman;*
F. T. BECKETT,
R. S. BELCHER,
M. S. BLAIKLOCK,
W. C. BOLIN,
H. F. BROWN,
J. F. BURNS,
E. E. CHAPMAN,
H. R. CLARKE,
S. B. CLEMENT,
R. L. COOK,
E. L. CRUGAR,
J. A. GORR,
ALBERT HANSEN,
R. S. HUBLEY,
P. B. JEFFRIES,
J. E. KING,
C. S. KIRKPATRICK,
M. F. LONGWILL,
A. F. MAISCHAIDER,
H. C. MUNSON,
L. T. NUCKOLS,
J. H. ROACH,
J. S. RUFF,
L. L. TALLYN,
H. M. TREMAINE,
J. W. WILLIAMS,
W. W. WYSOR,
R. C. YOUNG,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

1. Revision of Manual (no recommendation).
2. Anti-Splitting Devices (Appendix A).
3. Extent to which Specifications are being adhered to (Appendix B).
4. Renewal of Switch Ties (Appendix C).
5. Report on Substitute Ties (Appendix D).
6. Method of Marking Ties to Indicate Acceptance (Appendix E).
7. Method of Tie Acceptance Inspection (Appendix F).
8. Traffic Unit for Use in Comparing Cross-Tie Life (Appendix G).
9. Report Data on Renewal Averages per Mile of Maintained Track (Appendix H).
10. Definitions of Species of Wood Included in Standard Specifications (no report this year).
11. Size of Hole for Preboring (Appendix 1).

Action Recommended

1. That the report on Anti-Splitting Devices, Appendix A, be received as information.

2. That the report on Adherence to Specifications, Appendix B, be received as information, and the diagram be included in the Manual as part of the Specifications for Cross-Ties.

3. That the report on Renewal of Switch Ties, Appendix C, be adopted and the addition to the Manual, as indicated in Appendix C, be made.

4. That the report on Substitute Ties, Appendix D, be received as information.

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A

5. That the report of progress on the Marking of Ties, Appendix E, be received as information and the subject continued.

6. That the report of progress on the Method of Tie Acceptance Inspection, Appendix F, be received as information and the subject continued.

7. That the report on Traffic Unit for Comparison of Cross-Tie Life, Appendix G, be adopted and the subject discontinued.

8. That the report on Renewals per Maintained Mile, Appendix H, be received as information and the subject continued.

9. That the report on Size of Hole for Preboring, Appendix I, be adopted and the recommendations incorporated in the Manual.

Recommendations for Future Work

1. Revision of Manual.
2. Continue investigations and report on anti-splitting devices.
3. Continue investigation and report on adherence to specifications.
4. Report on substitute ties.
5. Complete report on marking ties for acceptance.
6. Complete report on methods of tie acceptance inspection.
7. Continue, as a yearly report, the report on ties renewed per maintenance mile.
8. Report on best shape of cut spike point for use in prebored ties.

Respectfully submitted,

THE COMMITTEE ON TIES,

W. J. BURTON, *Chairman.*

Appendix A

(2) ANTI-SPLITTING DEVICES

E. L. Crugar, Chairman, Sub-Committee; R. S. Belcher, H. F. Brown, H. R. Clarke, P. B. Jeffries, M. F. Longwill, H. C. Munson.

Your Committee, not having completed its investigations, cannot make a final report this year.

The work this year has included the beginning of a study of the behavior of the anti-splitting irons and the ties through the period of the

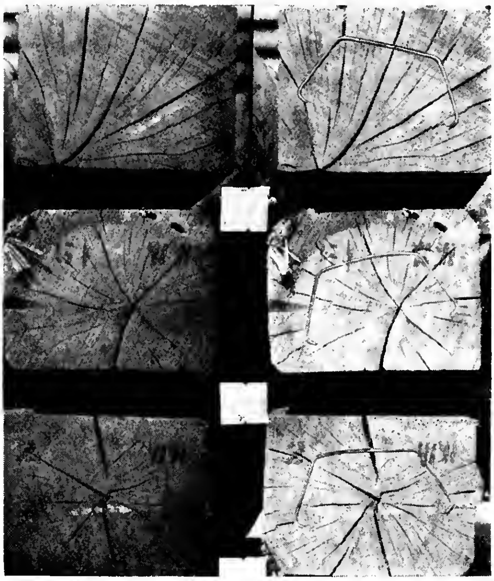


Fig. 1

natural seasoning. Three forms of irons are being watched on four kinds of wood in sizes 4 and 5 ties.

For this test, "C" irons, "S" irons, and a patented iron are being used. The ties are white and red oak, white birch and hard maple. The oak ties were produced at Sturgis, Mississippi, and were cut in July, 1928. They represent a fair average between the best and the poorest oak. The white birch ties were produced in Northern Minnesota and were cut early in the winter of 1927-8. The hard maple ties were produced at Iron Mountain and Winona, Michigan, and were also cut in July, 1928. Ties were selected which showed incipient checking.

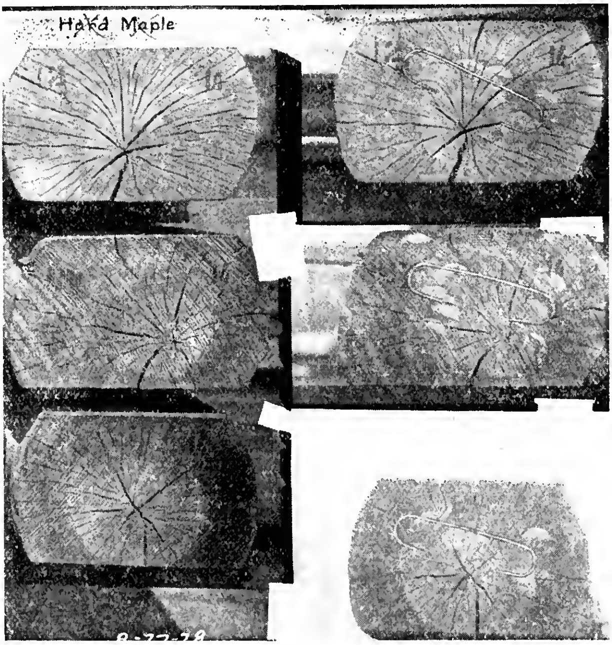


Fig. 2

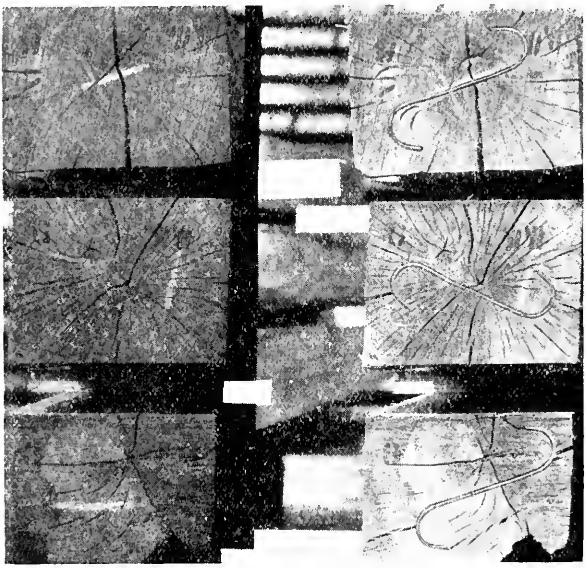


Fig. 3

These ties were assembled at the Burnside shops of the Illinois Central where the tests are being conducted with the ties exposed to the weather.

Photographs were taken of the ends of each tie immediately before and after the application of the irons. Photographs will be taken at about thirty-day intervals throughout the test. The ends of the ties were stenciled with a number and symbol for identification. A few ties of each kind of wood were not ironed, and will serve for comparison.

Some photographs taken at the beginning of the test showing the appearance of some of the ties before and after the application of the irons are included with the report.

The Committee also has under consideration a device to measure the force exerted by the splitting tie during the seasoning period. The results should indicate whether this force is sufficient to become a factor in the design of the anti-splitting device or whether the latter, if made strong enough to permit driving, will not then be amply strong to resist the tendency of the tie to split.

Appendix B

(3) ADHERENCE TO SPECIFICATIONS

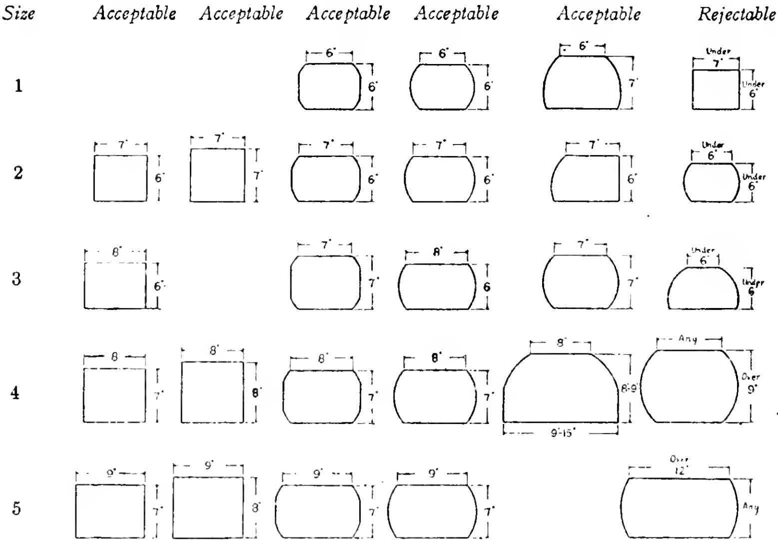
John Foley, Chairman, Sub-Committee; M. S. Blaiklock, J. F. Burns, R. L. Cook, J. A. Gorr, Albert Hansen, J. E. King, C. S. Kirkpatrick, R. C. Young.

In April, 1928, observations were made of ties at three commercial wood preserving plants in the vicinity of St. Louis. Over a million cross ties of hardwoods (mostly oak) and of southern pines provided examples of the inspection given by eight railroads in Arkansas, Illinois, Mississippi and Missouri.

These ties in general showed closer adherence to standards than was the case when ties were examined at two of the plants in 1925. There was less decay present in the accepted ties than was the case three years ago. This improvement is encouraging, and adds to the proof on every hand that cross ties in accordance with the standard specifications are to be had by any railroad which is not careless or reckless.

The few railroads owning the bulk of the ties represented among those observed varied only slightly in their application of the standard specification to the inspection of ties with reference to their size. Differences due to variations in practice when deciding the standard sizes at which ties of unusual shapes or of excessive dimensions are acceptable result in a lack of uniformity which would be remedied to a great extent if inspection were governed by instructions within the scope of the following diagram, which is recommended for adoption and inclusion in the Manual of Recommended Practice as a part of the specification for cross-ties.

Application of the Specification for Cross-Ties



Appendix C

(4) DEVELOP BEST PRACTICE FOR SWITCH TIE RENEWALS

W. C. Bolin, Chairman, Sub-Committee; F. T. Beckett, M. S. Blaiklock, H. F. Brown, P. B. Jeffries, J. E. King, H. C. Munson, L. L. Tallyn.

The Committee reported to the 1927 Convention the results of a questionnaire submitted to a group of selected railroads concerning switch tie renewal practice. See Volume 28 or Bulletin 292, Appendix F, page 205. The information developed a variation in the practice of switch tie renewals.

Last year the Committee gave reasons for and against each of the two methods of renewal and pointed out why the individual method was the better. It was the understanding last year that if nothing further was developed during the year to indicate a change from the individual renewal plan, the Committee would bring in a recommendation this year for inclusion in the Manual.

Recommendations

That an addition be made to the sentence on page 106 of the 1921 Manual to make this read—"The practice of single tie renewal is recommended *for both cross-ties and switch ties.*"

Appendix D

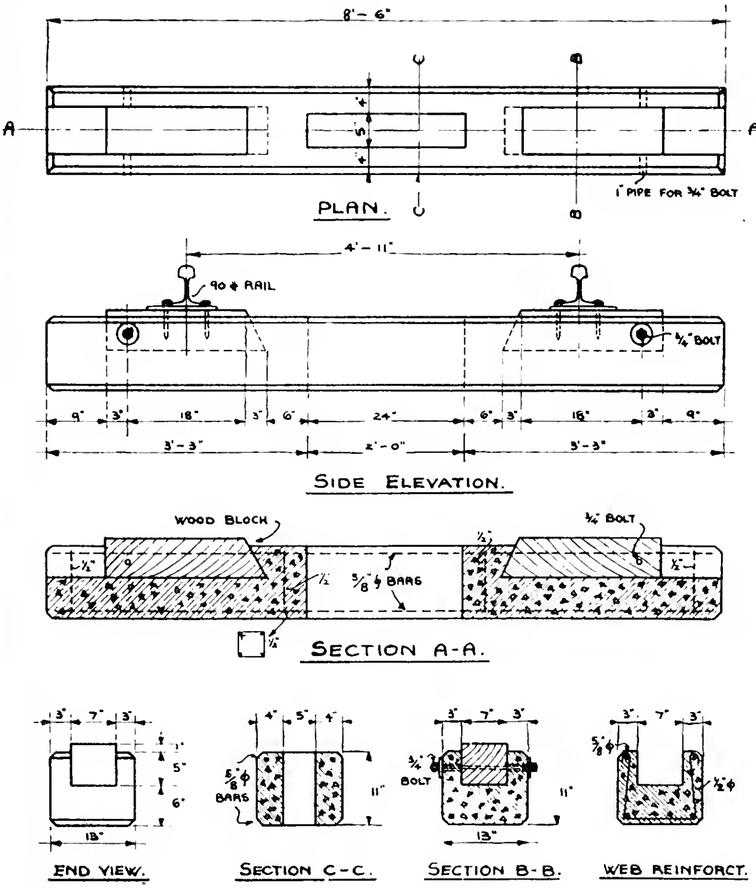
(5) REPORTS FROM RAILWAYS MAKING TESTS OF SUBSTITUTE TIES

S. B. Clement, Chairman, Sub-Committee; W. W. Wysor.

Atlanta and West Point Railroad

Reported by S. R. Young, Assistant Chief Engineer.
Date—June 20th, 1928.
Kind—Duke, Reinforced Cross-Tie.

This is a new design of tie—the details of which are shown on the accompanying drawing. On June 20th, 1927, ten Duke ties were installed in main track on the Atlanta and West Point Railroad at Louise, Ga. The first cost is reported to have been too high for any extensive installation although it is not known what the cost would be on a large production



REINFORCED CONCRETE CROSS TIE—ATLANTA & WEST POINT RAILROAD basis. They have been installed only a short time and appear to have been giving excellent service.

Bangor and Aroostook Railroad

Reported by P. C. Newbegin, Chief Engineer.
Date—June 8th, 1928.
Kind—Maine Concrete.

These ties have given good service and have shown no deterioration whatever to the date of last inspection, May 30th, 1928. None of them have been removed.

Duluth and Iron Range Railroad

Reported by W. A. Clark, Assistant to General Manager and Chief Engineer.
Date—June 13th, 1928.
Kind—Carnegie and Hatch.

Carnegie—No change reported during the year.

Hatch—Seven of these ties are in good condition but the other four show more or less disintegration of the concrete; three to the extent that the reinforcing is partially exposed while one of them will soon have to be removed.

Duluth, Missabe & Northern Railway Company

Reported by E. H. Dresser, Chief Engineer.
Date—June 5th, 1928.
Kind—Carnegie and Kimball.

Carnegie—Of the 22,380 Carnegie ties installed in 1908 and 1909, 20,087 remain in track, a reduction of 271 during the year.

Kimball—The thirty Kimball ties installed in 1914 are all in place and giving good service.

Elgin, Joliet and Eastern Railway

Reported by Arthur Montzheimer, Chief Engineer.
Date—June 29th, 1928.
Kind—Bates and Carnegie.

Bates Concrete—The 62 Bates ties installed in 1912 are still in track.

Carnegie Steel Cross-Ties and Switch Ties—Carnegie steel cross-ties (Section M-21) have been installed at various times.

Number placed in track		15,514
Removed 1916	50	
1917	260	
1918	182	
1919	453	
1920	306	
1921	1,165	
1922	641	
1923	2,620	
1924	1,341	
1925	262	
1926	550	
1927	2,399	
1928 (to April 30th)	1,158	
		11,383
Number remaining in track		4,127

The Carnegie Steel Switch Ties are of Section M-21 and are in yard tracks with heavy switching. The number of switch ties placed and removed are as follows:

Year	*Lin. Ft. of Steel Sw. Ties Used in Renewals*	*Lin. Ft. of Steel Sw. Ties Taken Up A/C Renewals*	*Lin. Ft. of Sw. Ties Used in Construction*	*Lin. Ft. of Steel Sw. Ties Taken Up A/C Track Retired*
1912	30,452	......	5,580	......
1913	196,333	......	11,527	430
1914	142,939	......	5,135	......
1915	58,314	......	2,023	1,615
1916	17,856	10	7,120	16,498
1917	3,789	1,907	8,623	17,340
1918	4,511	3,006	6,564	5,453
1919	6,483	526	1,582	1,582
1920	575	22,737	2,588	2,774
1921	4,712	24,855	717	4,744
1922	241	21,903	444	527
1923	846	19,451	.....	.....
1924	2,300	18,124	441	1,394
1925	184	33,700	.....	2,271
1926	1,708	37,098	255	2,550
1927	.....	142,954	2,004	945
To April 30th, 1928	.....	55,001	.....	.....
	471,239	381,272	54,603	58,123

Linear feet of Carnegie switch ties used in renewals and construction	525,842
Linear feet of Carnegie switch ties removed account renewals	381,272
Linear feet of Carnegie switch ties removed account track retired	58,123
Linear feet of Carnegie switch ties in track, May 1st, 1928	86,447

Long Island Railroad

Reported by J. T. Ridgely, Engineer Maintenance of Way.
Date—October 5th, 1928.
Kind—Carnegie and King Foreign.

Carnegie—In 1909, thirty Carnegie ties were installed at Hicksville, New York. During the year, twelve of these were removed, leaving only six of the ties originally installed, still in track.

King Foreign—The King Foreign cross-tie is described as consisting of two concrete blocks 3 feet long, 8 inches wide by 8 inches deep, connected by a 1¼-inch rod threaded male and female to maintain proper gage. The system of reinforcing provides for insulation. The rail is held by clips bolted into concrete block. Thirty-three of these ties were installed in track number one, Jamaica Station, L. I., in June, 1924.

Los Angeles Railway

Reported by B. J. Eaton, Engineer Way and Structures.
Date—June 11th, 1928.
Kind—McDonald Concrete.

None of the McDonald concrete ties are reported as having been removed from track during this year.

Pennsylvania Railroad—Eastern and Central Regions

Reported by T. J. Skillman, Chief Engineer.
Date—September 27th, 1928.
Kind—Riegler, Snyder, Silver and Brown.

Riegler—This installation is described in Vol. 24, page 241, and Vol. 27, page 722, of Proceedings A.R.E.A. These ties were installed in the heavy service, high speed tracks of the Eastern Division just west of Emsworth, Pa., in May, 1908. It is now reported that this test is regarded as practically closed, as repairs would have to be made to continue the ties in service.

Snyder Composite—This tie is illustrated in Vol. 13, page 352, of Proceedings A.R.E.A. In 1927, 64 of these ties failed and were removed from track.

Silver Combination Steel Concrete—This test has not been previously reported, but Silver ties installed on the New York Central are described in Vol. 23, page 248, Proceedings A.R.E.A. In November, 1922, 102 ties were installed in the eastward track of the Trenton Branch, New York Division, just west of Morrisville, Pa. The track was laid with P.S. 130-lb. rail, cinder ballast. The ties were laid continuously spaced 5 feet 6 inches, centre to centre, or six ties to a 33-foot rail length, 33 being placed under joints. The traffic is heavy, exclusively freight at slow speed (about 5 m.p.h.). In six years, 57 per cent of these ties have failed completely and have been removed from track. In November, 1922, 148 Silver ties were installed on the Atglen & Susquenhanna Branch, Philadelphia Division, just east of Atglen, Pa. Track and traffic conditions were similar to those in the Morrisville installation except that the ties were not installed in face but were alternated with wooden ties. Four wooden ties were replaced by each Silver tie and four wooden ties were left between each Silver tie. In March, 1923, all of the ties in the Atglen test were removed from track, as 86 per cent had completely failed. In September, 1924, 14 Silver ties of an improved design were installed at Morrisville. They are reported to be apparently in good condition after about four years' service although a few of them appear to be cracking transversely at the centre.

Brown Concrete—(These have also been referred to as Casey ties). The installations, 1925, at Hays and Aspinwall, Pa., are described in Vol. 28, page 196, Proceedings A.R.E.A. Of the five hundred and ten ties originally installed, forty-six have been replaced on account of breakages. In 1927, and 1928, a number of installations of an improved design of Casey ties were made at various points on the Eastern and Central Regions of the Pennsylvania Railroad and these, including a total of approximately 25,000 ties, comprise the most elaborate and impressive test of reinforced concrete ties, that has been made by any railway in America. The details of this revised design of Casey tie are shown in the accompanying drawings. Detail reports of examinations of the six installations on the Eastern Region made about ten months after they had been installed are as follows:

Three thousand six ties of this design were installed in the eastward freight track (No. 1) on the Middle Division, west of Bellwood, Pa., in July, 1927. They were installed in face with new P.S. 130-lb. rail, 22 per 39-ft. rail; track dug down to sub-grade and clean stone ballast put in. This is a track of very heavy service, exclusively freight.

An examination April 10th, 1928, developed the following: About 40 showed slight tension cracks, none of which appear to be serious. In addition 11 ties showed serious cracks, breaks or crushing. Of these 7 were crushed or broken under the rail seat, 4 being joint ties and 3 intermediate ties. Three ties, all intermediate, had the concrete broken off at the end of the reinforcing running from 5½ to 9 inches from the end of the tie, one tie intermediate, was spalled under the rail seat but not broken. None had been renewed.

One thousand four hundred eighty-six ties of this design were installed in the eastward freight track, on the Philadelphia Division, east of Highspire, Pa., in July, 1927. They were installed in face with new P.S. 130-lb. rail, 22 per 39-ft. rail, with clean cinder ballast. This is a track of heavy service, exclusively freight.

An examination in April, 1928, developed the following: 70 ties showed slight tension cracks, none of which appeared to be serious. In addition, 16 ties showed more serious cracks, breaks or crumbling. One tie, intermediate, crushed under rail seat. Five intermediate and one joint ties crushed under rail seat and broken. One intermediate tie spalled under rail seat but not broken. Two ties broken under rail in insulated joint. Five intermediate and one joint ties broken through between rails, but not spalled. None had been renewed.

Five hundred seventeen ties of this design were installed in the eastward main track of the Atglen & Susquehanna Branch, Philadelphia Division, between Mile Posts 31 and 32, in July, 1927. These were installed under P.S. 130-lb. rail with clean cinder ballast. These ties were not installed in face but were spotted in for renewal among wooden cross ties. This is a track of very heavy service, exclusively freight.

An examination May 3d, 1928, developed the following: 29 ties show slight tension cracks which do not appear to be serious. In addition, 12 ties show serious cracks and breaks. Seven ties are cracking transversely between rails. Four ties (one in joint) are broken under the rail and crumbling. One tie broken through between rails and under one rail. None had been renewed.

Nine hundred seventy ties of this design were installed in the main (single) track of the Columbia & Port Deposit Branch, Maryland Division, east of Haines Station, Pa., in July and August, 1927. They were installed in face with new 130-lb. rail in stone ballast, 22 per 39-ft. rail length. This is on a relocation of line, heavy service, freight and passenger.

An examination of these ties in May, 1928, showed that 21 had developed serious cracks or fractures of the concrete. Six ties at the west end had been renewed, but these had been damaged in unloading them from cars.

One thousand nine hundred eighty-six ties of this design were installed in the main (single) track of the Columbia & Port Deposit Branch, Maryland Division, east of Conowingo, Maryland, in July and August, 1927. They were installed in face with new P.S. 130-lb. rail in stone ballast, 22 per 39-ft. rail length. This is on a relocation of line, heavy service, freight and passenger.

An examination of these ties in May, 1928, showed that 22 had developed serious cracks or fractures of the concrete. Seven had the ends broken off at the end of the reinforcing, one had the concrete shattered under the inside edge of rail, one was broken through and shattered inside the rail and 13 were cracked through inside of rail. None had been renewed.

One thousand nine hundred ninety-three ties of this design were installed in the main (single) track of the Columbia & Port Deposit Branch, Maryland Division, east of Octoraro Bridge, Maryland, in July and August, 1927. They were installed in face, with new P.S. 130-lb. rail, in stone ballast, 22 per 39-ft. rail length. This is on a relocation of line, heavy service, freight and passenger.

An examination of these ties in May, 1928, showed that 21 had developed serious cracks or fractures of the concrete. None had been renewed

Southern Pacific Lines

Reported by E. A. Craft, Engineer Maintenance of Way.
Date—September 10th, 1928.
Kind—U. S. Indestructible.

A recent inspection of the ties installed in 1916 near Eagle Pass, Texas, on the Galesvton, Houston & San Antonio Railway, indicates that they are in good condition. This installation is in main track, light service, used also for light yard switching. The ties installed in February, 1926, near Mile Post 355.52, Texas & New Orleans Railway, were in main track, heavy high speed passenger and freight service. They proved to be unsatisfactory and were all removed in November, 1927, due to failure of the ties by cracking through the middle and the difficulty in holding proper gage by means of the oak blocks set in the ties at the rail seats. The U. S. Indestructible tie is described and illustrated in Vol. 19, pages 400-402, Proceedings, A.R.E.A.

Terminal Railroad Association of St. Louis

Reported by H. J. Pfeifer, Chief Engineer.
Date—August 24th, 1928.
Kind—Miller.

This installation of 100 Miller ties in main track, west of Florissant Avenue, St. Louis, is described in Vol. 27, pages 724 and 732, Proceedings, A.R.E.A., and a photograph of the ties in track accompanies this report. The ties are reported to be in first class condition in every particular.

MILLER STEEL TIES—TERMINAL RAILROAD ASSOCIATION OF ST. LOUIS

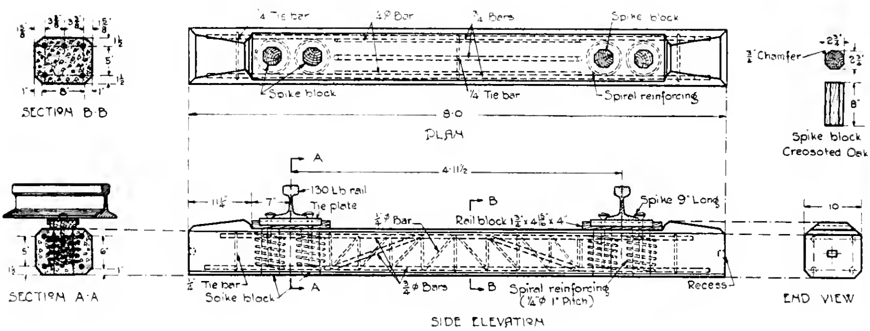
INSPECTION OF BROWN TIES ON PENNSYLVANIA RAILROAD BY MEMBERS OF TIE COMMITTEE

On October 18th, 1928, the Tie Committee inspected two lots of the Brown ties, located near Pittsburgh. One lot of 400 is located on the Monongahela Division, in the eastbound freight track of a four-track roadway. This installation is on a three-degree curve on a ballast-deck concrete-slab bridge. The ballast is crushed rock; the rail, 130-lb. P.S. The track was in good line and surface but is, of course, not subject to usual drainage difficulties or settlement of sub-grade.

The Brown ties at this location were the first of these installed, and were put in in November, 1925. They are of a slightly different pattern than the later installations. Of the original 400 at this location, 26 had been renewed prior to the inspection with ties of the improved design. The remainder were in good condition. Some showed tension cracks near their centres but the concrete appeared to be of excellent quality. Many of these ties had rolled somewhat due to the creeping of the rail. The fact that the thrust from the slot spikes or rail anchors is applied to the tie two or more inches above the top of the tie, because of the wooden blocks, provides a lever arm which causes the tie to roll. This difficulty could probably be overcome by a form of rail anchor which would bear against the side of the tie proper. The wood blocks were generally in good condition although some of them were somewhat shattered or broomed.

The other installation of Brown ties inspected by the Committee on October 18th, 1928, is at Edgewood on the middle, or No. 0, track of a five-track roadway, this track being used exclusively as freight "pull out" track at slow speed. There are 2500 ties of the improved design at this point and all were installed in August, 1928. The rail is 130-lb., P.S., relay, and the ballast, crushed rock. These ties are made of gravel concrete, and are said to have cost $4.14 each, exclusive of the cement, plates and fastenings. The concrete appeared to be of excellent quality and, when inspected, the ties were in perfect condition.

The Brown ties are the product of the Concrete Tie Company, were made by John F. Casey and Company, and have previously been referred to as Casey ties.



BROWN (CASEY) CONCRETE TIE—PENNSYLVANIA RAILROAD

ELECTRICAL CONDUCTIVITY OF CONCRETE CROSS-TIES

The following information relative to the reduction in the resistance of signal track circuits in recent extensive installations of Casey or Brown ties, has been supplied by W. C. Cushing, Engineer of Standards, Pennsylvania Railroad:

We have begun to receive reports from our signal maintainers that the resistance for signal track circuits has been greatly reduced, thus requiring shorter circuits with consequent additional expense.

First Case: In a track circuit 4400 feet in length, there are 1985 concrete cross-ties and 500 wood ties, the latter being largely in the centre of the section. Before the concrete ties were put in the ballast resistance was 12.3 ohms per thousand feet. After placing the concrete cross-ties readings taken under the same climatic conditions showed the resistance to be 1.1 ohms per thousand feet, and it was necessary to cut the section in the centre in order to get sufficient current at the relay end to operate properly in wet weather. This is an additional expenditure of $800.

Second Case: In a track circuit 2650 feet long with 1028 concrete cross-ties and 479 wood ties, and another one 1750 feet long with 945 concrete cross-ties and 21 wood ties, with clean ballast and track in good condition, it is estimated from measurements made that for minimum total

Railroad	Name of Tie	Location	Date Put In	Number Put In	Number Now In	Ballast	Rail Section Pounds	Traffic
Atlanta & West Point	Duke	Louise, Ga.	1927	10	10	Stone and Gravel	90	A.
Bangor & Aroostook	Maine	Hudson, Me.	1923-4	69	69	Gravel	85	A.
Duluth & Iron Range	Hatch	Two Harbors, Minn.	1923	11	11	Gravel	80	C.
	Carnegie	Various	1905	2,000	1,045	Gravel	80	C.
Duluth, Missabe & Northern	Carnegie	Various	1908-9	22,380	20,087	Stone	100	A.
	Kimball	Virginia, Minn.	1914	30	30	Gravel	100	C.
Elgin, Joliet & Eastern	Bates	Whiting, Ind.	1912	62	62	Gravel	85	C.
	Carnegie, Track	Various	1909-18	15,514	4,127	Gravel, Cinder and Slag	85-100	C.
	Carnegie, Switch	Various	1912-27	G525,842	G86,447	Gravel Cinder and Slag	85-100	E.
Long Island Railroad	Carnegie,	Hicksville, N.Y.	1909	30	6	Cinder	100	A.
	King Foreign	Jamaica Sta., L.I.	1924	33	33	Stone	100	B-1.
Los Angeles Railway	McDonald	Los Angeles, Cal.	1911	4,323	736	Concrete	87	B.
Pennsylvania Railroad Central Region	Riegler Concrete	Emsworth, Pa.	1908	15	15	Stone	130	A.
	Snyder Composite	Pittsburg Div. Yards	1907	2,255	1,855	Cinder	100	F.
	Casey Concrete (Mfg. by Concrete Tie Co.)	Aspinwall, Pa.	1925	100	78	Cinder	130	C.
		Hays, Pa.	1925	410	410	Stone	130	C.
		Monongahela, Pa.	1927	2,515	2,516	Cinder	130	A.
		Derry, Pa.	1927	1,978	1,978	Cinder	130	E.
		Conpitt Jct., Pa.	1927	2,843	2,843	Stone	130	C.
		Wilkinsburg, Pa.	1928	1,861	1,861	Stone	130	E.
		Pitcairn, Pa.	1928	3,324	3,324	Cinder	130	C.
		Tunnelton, Pa.	1928	2,385	2,385	Cinder	130	A.
Eastern Region	Silver Combination Steel Concrete (Mfg. by Permanent Railway Tie Corporation)	Morrisville, Pa.	1922	102	55	Cinder	130	C.
		Atglen, Pa.	1922	148	none	Cinder	130	C.
		Morrisville, Pa.	1924	14	14	Cinder	130	C.
	Casey Concrete (Mfg. by Concrete Tie Co.)	Bellwood, Pa.	1927	3,006	3,006	Stone	130	C.
		Highspire, Pa.	1927	1,486	1,486	Cinder	130	C.
		M.P's. 31-32, Atglen & Susquehanna Branch	1927	517	517	Cinder	130	C.
		Haines Sta., Pa.	1927	970	964	Stone	130	A.
		Octoraro Bridge, Md.	1927	1,993	1,993	Stone	130	A.
		Conowingo, Md.	1927	1,986	1,986	Stone	130	A.
Southern Pacific Lines G. H. & S. A. Railway	U. S. Indestructible	Eagle Pass, Texas	1916	23	23	Cinder	80	D.
T. & N. O. Railway	U. S. Indestructible	M.P.355,52	1926	100	none	Gravel	90	A.
St. Louis & San Francisco	Clark -Applegate	Springfield, Mo.	1914	125	125	Chats	85	C.
Terminal R. R. Assn. of St. Louis	Miller	St. Louis, Mo.	1924	100	100	Cinder	100	A.

A - High speed, heavy service, passenger and freight.
B - High speed, exclusively passenger
B.1-Slow speed, exclusively passenger
C - Heavy service, exclusively freight.

D - Main Track, light service
E - Yard Track with heavy switching
F - Yard Track with light switching or storage usage

Note:- G - Lineal feet.

ballast resistance of 0.4 ohm for the track circuit, the maximum length of concrete cross-ties should not be over 2400 feet.

Third Case: Another independent observer found that a 2800-foot circuit gave a resistance of less than 0.2 ohms, about the failing point for the circuit, as the relay was just about shunted by the track leakage.

These reports seem to be important in connection with experimental trials of concrete cross-ties.

Appendix E

(6) DEVELOP BEST PRACTICE FOR GRADING MARKS FOR TIES TO INDICATE ACCEPTANCE

W. C. Bolin, Chairman, Sub-Committee; H. F. Brown, H. R. Clarke, E. L. Crugar, R. S. Hubley, M. F. Longwill, L. L. Tallyn, R. C. Young.

A questionnaire has been submitted to the various railroads to develop the present practice. The results of this questionnaire will be incorporated in the report next year. This questionnaire follows:

QUESTIONNAIRE ON GRADE MARKS FOR TIES

1. Are individual ties marked by the railroad inspector who accepts them for the Railroad? If not, please explain why.
2. Does the mark applied by the inspector contain the following data?
   (a) Identification of the road.
   (b) Identification of the individual inspector.
   (c) Size at which accepted.
   (d) Classification as a guide to treatment; i.e., whether to be used, treated or untreated, and if treated whether of wood easily treated or difficult to treat.
   (e) Date or year of acceptance.
3. What character of mark is used; i.e., hammer, paint or other. Describe fully.
4. Has your practice with regard to acceptance marking been changed recently, and if so what were the considerations prompting the change?
5. If hammer is used, have you found any serious difficulty or objection?
6. Is the size indicated by a symbol on the hammer or by the number of blows struck? Please explain why.
7. How many different indications are employed in marking ties? For instance, in addition to size, are the ties group-marked as Ua, Ub, Uc and Ud, Ta, Tb, Tc, and Td, etc.
8. Are refused ties designated by mark or by absence of acceptance mark?
9. Do you consider it desirable to so mark the ties that the inspectors identity and size marks will be preserved until insertion in the track? Please give reasons either for or against.
10. Is it desirable for the user of the tie to have the size marks as an aid in properly using the ties?
11. Submit sample plans of marking equipment and methods of marking.

Appendix F

(7) METHODS AND RULES FOR TIE ACCEPTANCE INSPECTION

R. L. Cook, Chairman, Sub-Committee; J. F. Burns, John Foley, R. S. Hubley, P. B. Jeffries, L. T. Nuckols.

The following questionnaire has been submitted to the membership:

QUESTIONNAIRE

1. Do you have inspectors of cross ties? If so, state number.
2. Are they a regularly organized force?
3. On what department roll are they carried?
4. To whom do they report?
5. From what sources are inspectors of cross-ties recruited?
6. What previous training and experience is required?
7. Are they instructed in their duties? If so, (a) by whom? (b) furnish copy of instructions.
8. Have you found instructions supplementary to the standard specifications of the A.R.A. necessary for the acceptance of satisfactory cross ties? If so, (a) explain why; (b) furnish copy of instructions.
9. With what equipment are inspectors of cross ties provided?
10. To what supervision is their work subjected?
11. If the inspector's identity is not disclosed by marks applied to ties, how is his work checked?
12. Are inspectors of cross ties used for other phases of tie procurement; i.e., for stimulating production, negotiating purchases, etc.?
13. Are inspectors of cross ties confined to a given territory? If not, is service in a given territory limited to any period?
14. Are they employed continuously? If not,
    (a) During what period are they employed?
    (b) To what service are they assigned when not employed as inspectors of cross ties?
15. What are the lines of advancement for inspectors of cross ties?
16. Do inspectors of cross ties also inspect switch and bridge ties and other forest products?
17. How many inspectors are regularly engaged in the inspection of forest products?
18. Furnish outline of your inspection organization.

This data will be collected and assembled and definite recommendations developed.

Appendix G

(8) TRAFFIC UNIT FOR USE COMPARING CROSS-TIE LIFE

A. F. Maischaider, Chairman, Sub-Committee; J. A. Gorr, A. Hanson, L. T. Nuckols, J. H. Roach, H. M. Tremaine.

Your Committee has previously attempted to work out a unit by which the effects of traffic on the life of cross-ties can be equated for use in comparison between individual railroads.

It is the thought of your Committee that the average cost of tie renewals per maintained mile, so adjusted for differences in average traffic, will give results as nearly comparable as the character of the data and the variables involved will permit.

The effect of traffic on the life of cross-ties no doubt depends to a certain extent on whether the ties are treated or untreated. In other words, with an untreated tie the use factor may only amount to, say, 30 per cent, whereas with a treated tie in the same location the use factor may be 50 per cent or more. However, it has not seemed possible to take this consideration into the present recommendations.

In selecting the recommended unit, consideration has been given to available statistics, but too great refinement has been avoided.

It has also been borne in mind that traffic statistics available include traffic handled over trackage rights, and to this extent the unit will be in error, depending upon the relative importance of this factor. However, in most cases this unbalancing is largely compensated for by reciprocal trackage rights.

If a railroad has only freight traffic, the proper unit would probably be freight "gross-ton-miles" and while, on the majority of railroads, the proportions of freight and passenger traffic are generally similar, yet there are some cases where the proportion of passenger traffic is greatly dissimilar from that of the average railroad. Your Committee has therefore felt it desirable to use a unit which will reflect passenger, as well as freight, traffic. The unit recommended is a combination of freight gross-ton-miles, including locomotives, and passenger gross-ton-miles, including locomotives.

"Freight gross-ton-miles" is readily available and can conveniently be obtained for each Class 1 railroad from the summary of Operating Statistics issued by the Bureau of Railway Economics. "Passenger gross-ton-miles" is not readily available from any report and the Committee therefore recommends its estimation, unless the actual is known, by assuming the average weight of pasenger cars, this average to be multiplied by the passenger car miles to give passenger car ton-miles. In the absence of a closer figure, your Committee recommends 72 tons as determined by the Mechanical Division, A. R. A. This figure of 72 tons may be somewhat high for light passenger trains.

Passenger "locomotive ton-miles" is not available, therefore, as an allowance for passenger locomotives, the Committee recommends the addition of one-third to the total passenger gross-ton-miles. As an allowance for speed, the Committee recommends a factor of one and one-half; or in other words, assumes that it takes one and one-half ton-miles of freight, including locomotives, to equal one ton-mile of passenger, including locomotives, as regards the damaging effect on ties.

The adjusted traffic is therefore the sum of freight gross-ton-miles, including locomotives, and passenger gross-ton-miles, including locomotives, as estimated above, with the passenger gross-ton-miles increased by 50 per cent as an allowance for speed. This formula can be expressed algebraically as follows:

Adjusted traffic =	Freight gross-ton-miles plus passenger car miles × 144
Traffic Density Unit =	Adjusted traffic divided by miles of maintained track — or,
Traffic Density Unit =	Freight gross-ton-miles plus passenger car miles multiplied by 144 and the sum divided by miles of maintained track.

This formula is in reality quite simple and the necessary figures can be obtained from the summary of Operating Statistics—Class 1 Railroads, issued monthly and yearly by the Bureau of Railway Economics.

Appendix H

(9) REPORT DATA ON AVERAGE TIES RENEWED PER MILE OF MAINTAINED TRACK

J. H. Roach, Chairman, Sub-Committee; M. S. Blaiklock, John Foley, J. E. King, A. F. Maischaider, J. S. Ruff, L. L. Tallyn, W. W. Wysor.

Schedule No 513 of the annual reports to the Interstate Commerce Commission covering tie renewal statistics was modified at the request of the Committee to include the essential data. The returns for the year 1927 are the first in the revised form and afford the basis for the information shown in the following tabulations.

The information shown in Table A was assembled by the Bureau of Railway Economics from the returns made in Schedule 513 by the railroads enumerated. The figures shown in column 8 are the miles of maintained track exclusive of track occupied by switch ties, etc., and the figures in column 9 are the estimated number of ties in all maintained tracks exclusive of switch ties, etc., corresponding with the maintained mileage shown in column 8. The "item" numbers shown in the headings of columns 8, 9 and 10 refer to the items reported in Schedule 513.

Table B has been prepared from the information shown in Table A. Attention is called to the possibility of error in some of the individual returns to the Commission and several changes in the reported figures have been made in the tables as result of correspondence with certain railroads in cases where errors were plainly evident. It was impossible, however, to undertake a complete check of the figures reported by each road.

Considerable variation will be noted in the figures in some of the columns in Table B which may be accounted for in part by the fact that both Tables A and B represent renewals for one year only and the renewals for any individual road may have been abnormal for the one year. The difference in cost per tie, column 6, may be due to the kind, size, specifications or amount of freight paid, depending upon the location of the road with respect to the source of production.

TABLE A

CROSS TIES LAID IN REPLACEMENT ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended Dec.31, 1927.

Road	Wooden Ties Untreated (U)		Wooden Ties Treated (T)		Ties Other Than Wood (S)	Total Ties Applied	Miles of Maintained Tracks (Item 24)	Estimated number Ties in all Maintained Tracks (Item 25)	Estimated Miles of Maintained Tracks Occupied by Switch Ties, etc. (Item 26)
	Number	Average Cost	Number	Average Cost					
1	2	3	4	5	6	7	8	9	10
NEW ENGLAND ROADS:									
Atlantic & St. Lawrence	13,628	$1.39	44,124	$1.75	-	57,752	260.39	772,799	17.01
Bangor & Aroostook	162,608	0.7425	-	-	-	162,608	836.95	2,414,197	34.29
Boston & Maine	427,989	1.19	634,632	1.86	-	1,062,621	3,982.67	10,750,000	195.00
Canadian Pacific (lines in Me.)	15,587	0.744	49,132	.1497	-	65,719	224.84	616,800	10.88
Canadian Pacific (Lines in Vt.)	10,353	0.75	29,999	1.46	-	40,352	135.25	387,470	12.39
Central Vermont	63,432	1.04	119,472	1.94	-	182,904	594.91	1,900,000	25.73
Maine Central	361,271	1.0851	-	-	-	361,271	1,419.67	4,306,000	55.23
New York Connecting	-	-	1,618	2.09	-	1,618	26.03	83,300	0.27
New York, New Haven & Hartford	362,572	1.25	1,123,929	1.79	-	1,486,501	4,472.07	13,425,000	502.75
Rutland	2,489	1.09	149,364	1.71	-	151,853	524.28	1,578,259	11.00
GREAT LAKES REGION:									
Ann Arbor	-	-	97,779	1.57	-	97,779	412.18	1,236,540	14.00
Buffalo, Rochester & Pittsburgh	16,516	1.14	107,794	2.20	-	124,310	1,075.22	2,669,366	116.74
Chicago & Erie	3,403	1.31	130,656	2.07	-	134,059	738.31	2,049,798	41.22
Chgo.,Det. & Can. Grd.Trk.Jct.	27,959	.85	25,242	1.46	-	53,201	145.86	462,458	8.60
Delaware & Hudson	161,198	1.95	179,640	2.46	142	340,980	1,630.95	4,522,130	96.00
Delaware, Lackawanna & Western	8,747	.87	260,315	1.72	-	269,062	2,588.36	7,505,432	127.04
Detroit & Mackinac	634	.54	77,244	1.124	-	77,878	398.455	1,213,607	7.851
Detroit & Toledo Shore Line	-	-	26,506	2.01	-	26,506	139.13	452,172	10.19
Detroit, Grand Haven & Milwaukee	44,291	1.04	67,229	1.40	-	111,520	357.65	1,141,155	20.42
Erie R.R.	133,222	1.483	795,836	2.066	-	929,058	4,295.65	11,426,429	136.12
Grand Trunk Western	112,604	1.18	170,191	1.50	-	282,795	922.48	2,990,074	28.48
Lehigh & Hudson River	848	1.47	9,916	1.99	-	10,764	135.29	352,000	.70
Lehigh & New England	11,194	1.14	22,937	1.95	-	34,131	298.93	837,506	34.45
Lehigh Valley	2,985	1.08	311,784	1.91	-	314,769	3,429.35	9,288,844	281.00
Michigan Central	36,100	.97	491,221	2.14	-	527,321	3,588.75	11,164,000	283.88
Monongahela	49,620	1.62	5,536	2.14	-	55,156	241.54	734,281	30.20
Montour	5,818	1.55	17,039	2.68	-	22,857	71.04	204,300	8.18
New Jersey & New York	2,364	1.85	5,781	2.27	-	8,145	54.08	138,444	2.21
New York Central	125,916	1.10	2,090,546	2.11	-	2,216,462	16,161.13	46,950,796	1,372.71
New York, Chicago & St. Louis	4,024	.882	515,339	1.986	274	519,637	2,551.54	7,943,214	199.44
New York, Ontario & Western	1,148	1.07	150,563	1.84	-	151,711	961.57	2,616,459	43.044
New York, Susquehanna & Western	6,888	1.31	43,042	1.76	-	49,930	228.74	585,574	16.89
Pere Marquette	129,902	1.19	474,489	1.37	-	604,391	2,918.08	8,756,038	166.91
Pittsburgh & Lake Erie	3,033	.93	94,914	2.40	-	97,947	977.00	2,867,174	158.08
Pittsburgh & Shawmut	44,098	1.11	-	-	-	44,098	139.85	347,000	14.00
Pittsburgh & West Virginia	17,804	1.7362	-	-	-	17,804	165.340	443,848	12.241
Pittsburg, Shawmut & Northern	67,123	1.298	3,854	2.227	-	70,977	246.55	689,873	11.91
Ulster & Delaware	15,777	1.712	-	-	-	15,777	164.37	435,000	4.89
Wabash	23,462	1.03	747,585	1.58	-	771,047	3,553.00	10,414,598	247.00

TABLE A

GROSS TIES LAID IN REPLACEMENT ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended Dec. 31, 1927.

Road	Wooden Ties Untreated (U)		Wooden Ties Treated (T)		Ties Other Than Wood (S)	Total Ties Applied	Miles of Maintained Tracks (Item 24)	Estimated number Ties in all Maintained Tracks (Item 25)	Estimated Miles of Maintained Tracks Occupied by Switch Ties, etc. (Item 26)
	Number	Average Cost	Number	Average Cost					
1	2	3	4	5	6	7	8	9	10
CENTRAL EASTERN REGION:									
Akron, Canton & Youngstown	75,675	$ 1.343	-	-	-	75,675	220.07	665,000	11.89
Atlantic City	-	-	33,519	2.34	-	33,519	305.51	879,696	12.77
Baltimore & Ohio	72,886	.77	1,818,537	1.63	6	1,891,429	10,685.17	27,850,245	908.00
Baltimore, Chesapeake & Atlantic	19,602	1.367	-	-	-	19,602	106.23	277,564	7.10
Bessemer & Lake Erie	106,030	1.86	8,494	2.16	3,612	118,136	543.28	1,601,654	38.35
Buffalo & Susquehanna	59,637	1.50	-	-	-	59,637	299.24	843,388	10.18
Central of New Jersey	-	-	123,004	1.99	-	123,004	1,773.88	4,025,299	246.62
Chicago & Eastern Illinois	513	1.199	200,916	1.548	-	201,429	1,686.31	5,059,063	135.86
Chicago & Illinois Midland	370	1.39	44,776	1.62	-	45,146	151.06	432,813	6.94
Chicago, Indianapolis & Louisville	3,072	.90	101,487	1.36	2,004	106,563	943.70	2,687,178	73.67
Cincinnati Northern	132	.87	65,428	1.989	-	65,560	272.21	782,069	6.87
Cleveland, Cincinnati, Chicago & St. Louis	472	.85	454,297	1.94	-	454,769	4,075.73	13,207,974	273.29
Detroit, Toledo & Ironton	3,885	1.26	88,955	1.94	-	92,840	631.29	1,818,515	39.30
Elgin, Joliet & Eastern	61,456	1.1796	162,665	1.4363	* 1,493	225,614	856.27	2,661,363	126.68
Evansville, Indianapolis & Terre Haute	1,095	1.156	42,710	1.288	-	43,805	171.39	500,000	12.21
Hocking Valley	77,986	.95	224,626	1.89	-	302,612	831.523	2,629,755	48.147
Long Island	64,827	1.66	125,200	2.25	30	190,057	993.73	2,389,000	140.00
Pennsylvania R.R.	326,956	1.56	3,767,109	2.04	12,923	4,142,988	24,822.14	62,675,903	2,508.16
Perkiomen	-	-	10,159	2.14	-	10,159	51.06	147,859	3.65
Port Reading	250	0.74	12,148	1.83	-	12,398	71.68	206,640	5.91
Reading Co.	12,226	1.02	481,111	1.99	88	493,425	2,809.16	8,133,408	190.03
Staten Island Rapid Transit		-	10,730	1.77	-	10,730	112.17	283,608	8.86
West Jersey & Seashore	65	2.28	64,207	2.12	-	64,272	610.12	1,514,764	48.92
Western Maryland	352,384	1.15	63,870	1.88	-	416,254	1,200.60	3,457,728	112.714
Wheeling & Lake Erie	159,982	1.49	97,915	1.94	-	257,897	922.76	2,651,594	47.91
POCAHONTAS REGION:									
Chesapeake & Ohio	47,798	.84	1,110,920	1.35	-	1,158,718	3,863.54	11,637,114	288.22
Norfolk & Western	126,840	.72	909,715	1.51	-	1,036,555	4,461.62	13,606,489	79.93
Richmond, Fredericksburg & Potomac	150,357	1.19	-	-	-	150,357	414.51	1,066,400	41.43
Virginian	191,906	.863	96,858	1.676	-	288,764	887.68	2,514,982	73.08
SOUTHERN REGION:									
Alabama Great Southern	146,678	1.08	117,813	1.49	-	264,491	461.40	1,725,600	142.09
Atlanta & West Point	22,332	1.36	5,258	1.55	-	27,590	134.12	424,079	17.19
Atlanta, Birmingham & Coast	132,907	.98	168,088	1.28	-	300,995	799.36	2,302,157	32.80
Atlantic Coast Line	996,372	1.12	652,120	1.12	-	1,648,492	7,226.40	19,754,370	423.93
Central of Georgia	26,573	.60	518,607	.99	-	545,180	2,664.48	5,147,352	39.88
Charleston & Western Carolina	130,775	1.088	-	-	-	130,775	443.93	1,229,600	19.9
Cincinnati, New Orleans & Texas Pac.	136,129	1.08	186,086	1.40	-	322,215	702.76	2,168,620	75.72
Clinchfield	165,793	.96	150	.97	-	165,943	401.50	1,220,531	34.86
Columbus & Greenville	69,117	.98	48,018	1.54	-	117,135	202.74	642,280	14.71
Florida East Coast	56,602	1.21	114,589	1.36	-	171,191	1,583.96	4,175,000	70.0
Georgia R.R.	131,710	1.38	478	1.75	-	132,188	418.89	1, 302,135	61.22

*Includes 1,450 second-hand ties and 43 steel ties.

TABLE A

CROSS TIES LAID IN REPLACEMENT ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended Dec.31, 1927.

Road	Wooden Ties Untreated (U)		Wooden Ties Treated (T)		Ties Other Than Wood (5)	Total Ties Applied	Miles of Maintained Tracks (Item 24)	Estimated Number Ties in all Maintained Tracks (Item 25)	Estimated Miles of Maintained Tracks Occupied by Switch Ties, etc. (Item 26)
	Number	Average Cost	Number	Average Cost					
1	2	3	4	5	6	7	8	9	10
SOUTHERN REGION (Cont'd)									
Georgia & Florida	110,821	.74	-	-	-	110,821	464.55	1,237,998	16.00
Georgia, Southern & Florida	72,391	1.30765	72,422	1.6888	-	144,813	473.73	1,585,428	36.07
Gulf & Ship Island	27,613	1.39	107,839	1.21	-	135,452	381.51	1,101,414	33.23
Gulf, Mobile & Northern	59,461	.84	79,530	1.29	-	138,991	721.01	2,175,680	41.11
Illinois Central	57,727	1.23	1,301,036	1.22	-	1,358,763	8,418.69	24,298,095	526.70
Louisville & Nashville	337,008	.983	1,303,601	1.782	-	1,640,609	7,188.15	20,202,633	526.80
Louisville, Henderson & St. Louis	-	-	55,812	1.70	-	55,812	238.86	673,131	10.83
Mississippi Central	6,100	.832	30,408	1.181	-	36,508	190.91	571,978	7.46
Mobile & Ohio	459,713	.94	47,549	1.23	-	507,262	1,348.79	4,056,022	68.48
Nashville, Chattanooga & St. Louis	147,179	.81	416,517	1.43	-	563,696	1,766.69	4,846,222	129.02
New Orleans & Northeastern	41,919	1.12	79,121	1.49	-	121,040	322.10	886,889	34.68
New Orleans Great Northern	3,507	.44	68,309	1.29	-	71,816	280.40	920,392	4.21
Norfolk Southern	320,049	.85	-	-	-	320,049	1,153.43	3,067,204	58.00
Northern Alabama	67,157	.91326	-	-	-	67,157	134.51	422,198	24.01
Seaboard Air Line	1,274,232	1.15	60,807	1.31	-	1,335,039	5,470.96	16,763,196	216.90
Southern Ry.	2,545,530	1.0399	960,867	1.60576	-	3,506,397	9,037.53	28,661,211	847.71
Tennessee Central	156,291	.66	10,787	1.25	-	167,078	358.01	1,109,085	30.00
Western Ry. of Alabama	16,677	1.37	34,017	1.53	-	50,694	183.58	565,544	27.41
Yazoo & Mississippi Valley	44,877	1.25	567,827	1.29	-	612,704	2,411.51	7,079,230	157.63
NORTHWESTERN REGION:									
Chicago & North Western	140,928	.74	2,379,417	1.25	-	2,520,345	12,384.75	36,483,516	748.90
Chicago Great Western	185,125	1.00	246,613	1.25	-	431,738	1,953.14	5,621,300	67.72
Chicago, Milwaukee, St.Paul & Pacific	1,093,393	.62	3,310,320	1.12	-	4,403,713	15,446.35	43,317,416	450.00
Chicago, St.Paul, Minpls. & Omaha	233,406	.64	438,551	1.47	-	671,957	2,539.47	6,951,027	165.85
Duluth & Iron Range	96,043	.98	55,701	1.83	-	151,744	492.1	1,540,849	43.60
Duluth, Missabe & Northern	20,313	.8306	144,776	1.95	-	165,089	721.03	2,199,142	46.32
Duluth, So. Shore & Atlantic	247,636	.70	331	1.57	-	247,967	730.32	2,127,821	19.71
Duluth, Winnipeg & Pacific	93,172	.67	-	-	-	93,172	214.09	623,965	6.35
Great Northern	481,666	.70	1,589,794	1.12	61,443	2,132,903	10,059.77	31,357,934	547.58
Green Bay & Western	93,728	.79	-	-	-	93,728	283.22	788,160	1.901
Lake Superior & Ishpeming	49,700	.6524	-	-	-	49,700	226.90	680,700	15.96
Minneapolis & St. Louis	161,822	1.06	233,133	1.43	-	394,955	1,811.51	5,459,765	90.85
Minpls., St. Paul & S.S. Marie	1,024,593	.70	396,605	1.28	-	1,421,198	5,256.04	15,367,292	231.73
Northern Pacific	335,274	.64	1,202,326	1.25	18	1,537,618	9,722.40	26,380,939	602.26
Oregon-Washington R.R. & Nav. Co.	3,740	.45	568,830	.82	-	572,570	2,251.35	6,555,400	171.67
Spokane International	69,237	.5217	-	-	-	69,237	199.88	547,297	6.06
Spokane, Portland & Seattle	110,178	.67	100,952	1.06	-	211,130	664.07	1,911,747	42.32

TABLE A

CROSS TIES LAID IN REPLACEMENT ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended Dec. 31,1927.

Road	Wooden Ties Untreated (U)		Wooden Ties Treated (T)		Ties Other Than Wood (S)	Total Ties Applied	Miles of Maintained Tracks (Item 24)	Estimated number Ties in all Maintained Tracks (Item 25)	Estimated Miles of Maintained Tracks Occupied by Switch Ties, etc. (Item 26)
	Number	Average Cost	Number	Average Cost					
1	2	3	4	5	6	7	8	9	10
CENTRAL WESTERN REGION:									
Atchison, Topeka & Santa Fe	26,351	$0.98	1,987,709	$1.46	-	2,014,060	14,686.93	44,604,206	799.57
Bingham & Garfield	8,620	1.615	5,419	2.20	-	14,039	42.00	117,081	3.20
Chicago & Alton	448,808	1.20	-	-	999	449,807	1,631.43	4,896,533	108.21
Chicago, Burlington & Quincy	-	-	2,143,538	1.31	27,892	2,171,430	12,885.54	39,790,547	782.73
Chicago, Rock Island & Gulf	48	.88	152,189	1.321	3,658	155,895	568.46	1,736,378	23.53
Chicago, Rock Island & Pacific	18,674	.64	1,467,274	1.17	-	1,485,948	10,025.80	29,173,168	323.72
Colorado & Southern	60,894	.53	184,577	1.69	-	245,471	1,269.63	3,842,064	60.42
Denver & Rio Grande Western	266,320	1.056	522,255	1.211	-	788,575	3,599.00	10,696,240	161.33
Denver & Salt Lake	97,302	1.48	-	-	-	97,302	315.44	946,350	4.48
Fort Worth & Denver City	-	-	193,597	1.48	-	193,597	643.94	1,898,737	35.8
Los Angeles & Salt Lake	-	-	214,560	1.36	-	214,560	1,482.80	4,131,883	83.32
Nevada Northern	38,463	1.03	-	-	-	38,463	190.26	547,945	3.48
Northwestern Pacific	143,339	.81	-	-	-	143,339	581.07	1,718,224	52.53
Oregon Short Line	26	.79	666,566	1.15	-	666,592	3,331.88	9,288,843	180.68
Panhandle & Santa Fe	-	-	166,488	1.52	-	166,488	1,309.51	3,980,417	59.77
Quincy, Omaha & Kansas City	67,823	1.353	-	-	-	67,823	266.46	836,684	9.31
St. Joseph & Grand Island	71,650	1.45	-	-	-	71,650	327.10	912,784	22.83
Southern Pacific	447,173	1.01	2,355,873	1.53	-	2,803,046	12,463.39	36,465,128	958.63
Toledo, Peoria & Western	37,825	1.08	45,307	1.34	-	83,132	282.38	847,140	8.31
Union Pacific	490	1.22	1,172,366	1.17	-	1,172,656	5,878.00	16,588,000	519.00
Utah Ry.	5,016	.6846	6,245	1.639	-	11,261	108.70	310,000	1.2
Western Pacific	535,319	.847			-	535,319	1,302.22	3,686,000	32.82
SOUTHWESTERN REGION:									
Beaumont, Sour Lake & Western	-	-	30,390	1.36	-	30,390	104.66	313,000	4.94
Fort Smith & Western	72,939	.709	-	-	-	72,939	234.712	734,500	4.00
Fort Worth & Rio Grande	47,092	.98	21,264	1.51	-	68,356	245.36	777,300	13.67
Gulf, Colorado & Santa Fe	-	-	319,661	1.32	-	319,661	2,465.36	8,585,945	155.70
International-Great Northern	384	.514	411,312	1.18	-	411,696	1,523.50	4,367,400	67.47
Kansas City, Mexico & Orient	87,724	1.14	92,859	1.54	-	180,583	310.46	892,005	8.37
Kansas City, Mexico & Orient of Tex.	222,440	.60	224,622	1.29	-	447,062	544.18	1,501,915	11.30
Kansas City Southern	13,084	.82	150,641	1.46	-	163,725	1,152.10	3,609,644	52.43
Kansas, Oklahoma & Gulf	58,947	.92	153,379	1.80	-	212,326	370.56	1,164,055	10.03
Louisiana & Arkansas	20,964	.59	75,815	1.10	-	96,779	343.69	1,031,310	22.96
Louisiana Ry. & Nav. Co.	56,166	.788	45,598	1.238	-	101,764	435.03	1,392,096	9.53
Louisiana Ry. & Nav.Co.of Tex.	55,176	.92	4,608	1.47	-	59,784	228.52	690,592	12.71
Midland Valley	47,770	.92	75,342	1.78	-	123,112	436.30	1,352,274	11.78
Missouri & North Arkansas	149,444	.69	-	-	-	149,444	383.191	1,138,935	18.854
Missouri-Kansas-Texas	177	.87	617,844	1.285	-	618,021	2,471.41	7,299,700	150.81
Missouri-Kansas-Texas of Tex.	5	1.11	423,306	1.29.	-	423,311	1,847.39	5,406,200	147.24
Missouri Pacific	479,636	.84	2,143,571	1.11	-	2,623,207	9,817.13	28,293,000	672.65
New Orleans, Texas & Mexico	1,255	.964	65,891	1.34859	-	67,146	223.78	685,000	12.92

TABLE A

CROSS TIES LAID IN REPLACEMENT ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended Dec. 31,1927.

Road	Wooden Ties Untreated (U)		Wooden Ties Treated (T)		Ties Other Than Wood (S)	Total Ties Applied	Miles of Maintained Tracks (Item 24)	Estimated number Ties in all Maintained Tracks (Item 25)	Estimated Miles of Maintained Tracks Occupied by Switch Ties, etc. (Item 26)
	Number	Average Cost	Number	Average Cost					
1	2	3	4	5	6	7	8	9	10
SOUTHWESTERN REGION (Cont'd)									
St. Louis, Brownsville & Mexico	-	$ -	276,657	$ 1.26	-	276,657	689.66	2,110,000	29.55
St. Louis-San Francisco	597,546	.80	636,844	1.29	-	1,234,390	6,709.146	20,771,516	278.547
St. Louis, San Francisco & Texas	24,240	.93	14,673	1.39	-	38,913	108.20	342,769	14.15
St. Louis Southwestern	224	.81	381,794	1.40	7,663	389,681	1,088.62	3,087,654	113.98
St. Louis Southwestern of Tex.	147	.7828	240,457	1.435	-	240,604	1,031.22	2,983,040	82.49
San Antonio, Uvalde & Gulf	43	.83	61,524	1.36	-	61,567	348.42	978,000	9.12
Texarkana & Fort Smith	4	.84	14,291	1.92	-	14,295	159.02	492,502	7.95
Texas & New Orleans	259,691	1.18	1,000,677	1.56	-	1,260,368	6,300.66	17,708,966	379.83
Texas & Pacific	25,655	.944	938,140	1.265	-	963,795	2,454.03	7,725,208	177.89
Texas Mexican	13,227	1.24	55,544	1.71	-	68,771	199.821	575,484	Not reported
Trinity & Brazos Valley	70	.56	68,814	1.04	-	68,884	356.02	1,115,486	16.59
Wichita Valley	-	-	46,051	1.27	-	46,051	309.43	891,027	12.2
Galveston, Harrisburg & San Antonia [a]	5,388	1.40	88,065	1.75	-	93,453	2,825.01	7,317,965	134.02
Houston & Texas Central [a]	2,308	1.74	26,875	1.71	-	29,183	1,161.83	3,118,519	69.96
Houston East & West Texas [a]	1,678	1.10	5,035	1.49	-	6,713	258.17	656,358	17.87
Louisiana Western [a]	9,458	1.55	-	-	-	9,458	288.22	676,258	17.37
Morgan's La. & Tex. R.R. & S.S. Co. [a]	27,876	1.28	-	-	-	27,876	669.42	1,546,888	52.37

a Two months ended Feb. 28, 1927.

TABLE B

WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES

Calender Year Ended Dec. 31, 1927

Note: All figures are exclusive of Bridge and Switch Ties

Road	Miles of Maintained Track Occupied by Wooden Cross Ties (Col.8 - Table A)	Average Number of Wooden Cross Ties per Mile of Maintained Track	Total Number of Wooden Cross Ties Renewed 1927	Average Number of Wooden Cross Ties Renewed per Mile of Maintained Track	Weighted Average Cost per Wooden Cross Tie	Average Cost of Wooden Cross Tie Renewals Per Mile of Maintained Track	Average Percentage of Wooden Cross Tie Renewals
1	2	3	4	5	6	7	8
NEW ENGLAND ROADS:							
Atlantic & St. Lawrence	260.39	2968	57,752	222	$ 1.67	$ 371.	7.5
Bangor & Aroostook	836.95	2885	162,608	194	.74	144.	6.7
Boston & Maine	3,982.67	2699	1,062,621	267	1.59	425.	9.9
Canadian Pacific (Lines in Me.)	224.84	2743	65,719	292	1.31	383.	10.7
" " (" " Vt.)	135.25	2865	40,352	298	1.28	381.	10.4
Central Vermont	594.91	3194	182,904	307	1.63	500.	9.6
Maine Central	1,419.67	3033	361,271	254	1.09	277.	8.4
New York Connecting	26.03	3200	1,618	62	2.09	130.	1.9
New York, New Haven & Hartford	4,472.07	3002	1,486,501	332	1.66	551.	11.1
Rutland	524.28	3010	151,853	290	1.70	493.	9.6
GREAT LAKES REGION:							
Ann Arbor	412.18	3000	97,779	237	1.57	372.	7.9
Buffalo, Rochester & Pittsburgh	1,075.22	2483	124,310	116	2.06	239.	4.7
Chicago & Erie	738.31	2776	134,059	182	2.05	373.	6.5
Chgo.,Det.& Can.Grd.Trk. Jct.	145.86	3171	53,201	365	1.14	416.	11.5
Delaware & Hudson	1,630.95	2773	340,838	209	2.22	464.	7.5
Delaware, Lackawanna & Western	2,588.36	2900	269,062	104	1.69	176.	3.6
Detroit & Mackinac	398.455	3046	77,878	195	1.12	218.	6.4
Detroit & Toledo Shore Line	139.13	3250	26,506	191	2.01	384.	5.9
Detroit, Grand Haven & Milwaukee	357.65	3191	111,520	312	1.26	393.	9.8
Erie R.R.	4,295.65	2660	929,058	216	1.93	417.	8.1
Grand Trunk Western	922.48	3241	282,795	307	1.37	421.	9.5
Lehigh & Hudson River	135.29	2602	10,764	80	1.95	156.	3.1
Lehigh & New England	298.93	2802	34,131	114	1.68	192.	4.1
Lehigh Valley	3,429.35	2709	314,769	92	1.90	175.	3.4
Michigan Central	3,588.75	3111	527,321	147	2.06	303.	4.7
Monongahela	241.54	3040	55,156	228	1.67	361.	7.5
Montour	71.04	2876	22,857	322	2.39	770.	11.2
New Jersey & New York	54.08	2560	8,145	151	2.15	325.	5.9
New York Central	16,161.13	2905	2,216,462	137	2.05	281.	4.7
New York, Chicago & St. Louis	2,551.54	3113	519,363	204	1.98	404.	6.5
New York, Ontario & Western	961.57	2721	151,711	158	1.83	289.	5.8
New York, Susquehanna & Western	228.74	2560	49,930	218	1.70	371.	8.5
Pere Marquette	2,918.08	3001	604,391	207	1.33	275.	6.9
Pittsburgh & Lake Erie	977.00	2935	97,947	100	2.35	235.	3.4
Pittsburgh & Shawmut	139.85	2481	44,098	315	1.11	350.	12.7
Pittsburgh & West Virginia	165.34	2684	17,804	108	1.74	188.	4.0
Pittsburgh, Shawmut & Northern	246.55	2798	70,977	288	1.35	389.	10.3
Ulster & Delaware	164.37	2646	15,777	96	1.71	164.	3.6
Wabash	3,553.00	2931	771,047	217	1.56	339.	7.4

TABLE B

WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended Dec. 31, 1927

Note: All figures are exclusive of Bridge and Switch Ties.

Road	Miles of Maintained Track Occupied by Wooden Cross Ties (Col.8 - Table A)	Average Number of Wooden Cross Ties per Mile of Maintained Track	Total Number of Wooden Cross Ties Renewed 1927	Average Number of Wooden Cross Ties Renewed per Mile of Maintained Track	Weighted Average Cost per Wooden Cross Tie	Average Cost of Wooden Cross Tie Renewals Per Mile of Maintained Track	Average Percentage of Wooden Cross Tie Renewals
1	2	3	4	5	6	7	8
CENTRAL EASTERN REGION:							
Akron, Canton & Youngstown	220.07	3022	75,675	344	$ 1.34	$ 461.	11.4
Atlantic City	305.51	2879	33,519	110	2.34	257.	3.8
Baltimore & Ohio	10,685.17	2606	1,891,423	177	1.60	283.	6.8
Baltimore, Chesapeake & Atlantic	106.23	2613	19,602	185	1.37	253.	7.1
Bessemer & Lake Erie	543.28	2948	114,524	211	1.88	397.	7.2
Buffalo & Susquehanna	299.24	2818	59,637	199	1.50	299.	7.1
Central of New Jersey	1,773.88	2269	123,004	69	1.99	137.	3.1
Chicago & Eastern Illinois	1,686.31	3000	201,429	119	1.55	184	4.0
Chicago & Illinois Midland	151.06	2865	45,146	299	1.62	484.	10.4
Chicago, Indianapolis & Louisville	943.70	2847	104,559	111	1.35	150.	3.9
Cincinnati Northern	272.21	2873	65,560	241	1.99	480.	8.4
Cleveland, Cincinnati, Chicago & St.Louis	4,075.73	3241	454,769	112	1.94	217.	3.4
Detroit, Toledo & Ironton	631.29	2881	92,840	147	1.91	281.	5.1
Elgin, Joliet & Eastern	856.27	3108	224,121	262	1.37	359.	8.4
Evansville, Indianapolis & Terre Haute	171.39	2917	43,805	256	1.28	328	8.8
Hocking Valley	831.523	3163	302,612	364	1.65	601.	11.5
Long Island	993.73	2404	190,027	191	2.05	392.	8.0
Pennsylvania R.R.	24,882.14	2525	4,130,065	166	2.00	332.	6.6
Perkiomen	51.06	2896	10,159	199	2.14	426.	6.9
Port Reading	71.68	2883	12,398	173	1.81	313.	6.0
Reading Co.	2,809.15	2895	492,337	175	1.97	347.	6.1
Staten Island Rapid Transit	112.17	2528	10,730	96	1.77	170.	3.8
West Jersey & Seashore	610.12	2483	64,272	105	2.12	223	4.2
Western Maryland	1,200.60	2880	416,254	347	1.26	437.	12.0
Wheeling & Lake Erie	922.76	2874	257,897	279	1.66	463.	9.7
POCAHONTAS REGION:							
Chesapeake & Ohio	3,863.54	3012	1,158,718	300	1.33	399.	10.0
Norfolk & Western	4,461.62	3050	1,036,555	232	1.41	327.	7.6
Richmond, Fredericksburg & Potomac	414.51	2573	150,357	363	1.19	432.	14.1
Virginian	887.68	2833	288,764	325	1.14	371.	11.5
SOUTHERN REGION:							
Alabama Great Southern	461.40	3740	264,491	573	1.26	722.	15.3
Atlanta & West Point	134.12	3162	27,590	206	1.40	288.	6.5
Atlanta, Birmingham & Coast	799.36	2880	300,995	377	1.15	434.	13.1
Atlantic Coast Line	7,226.40	2734	1,648,492	228	1.12	255.	8.3
Central of Georgia	2,664.48	1932	545,180	205	.97	199.	10.6
Charleston & Western Carolina	443.93	2770	130,775	295	1.09	322.	10.6
Cincinnati, New Orleans & Texas Pacific	702.76	3086	322,215	458	1.26	577.	14.9

TABLE B

WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended Dec. 31, 1927

Note: All figures are exclusive of Bridge and Switch Ties.

Road	Miles of Maintained Track Occupied by Wooden Cross Ties (Col.8 - Table A)	Average Number of Wooden Cross Ties per Mile of Maintained Track	Total Number of Wooden Cross Ties Renewed 1927	Average Number of Wooden Cross Ties Renewed per Mile of Maintained Track	Weighted Average Cost per Wooden Cross Tie	Average Cost of Wooden Cross Tie Renewals Per Mile of Maintained Track	Average Percentage of Wooden Cross Tie Renewals
1	2	3	4	5	6	7	8
SOUTHERN REGION (Cont'd)							
Clinchfield	401.50	3040	165,943	413	.96	$ 396.	13.6
Columbus & Greenville	202.74	3168	117,135	578	1.21	699.	18.2
Florida East Coast	1,583.96	2636	171,191	108	1.31	141.	4.1
Georgia R.R.	418.89	3109	132,188	316	1.38	436.	10.2
Georgia & Florida	464.55	2665	110,821	239	0.74	177.	9.0
Georgia, Southern & Florida	473.73	3347	144,813	306	1.50	459.	9.1
Gulf & Ship Island	381.51	2887	135,452	355	1.25	444.	12.3
Gulf, Mobile & Northern	721.01	3018	138,991	193	1.10	212.	6.4
Illinois Central	8,418.69	2886	1,358,763	161	1.22	196.	5.6
Louisville & Nashville	7,188.15	2811	1,640,609	228	1.62	369.	8.1
Louisville, Henderson & St. Louis	238.86	2818	55,812	234	1.70	398.	8.3
Mississippi Central	190.91	2996	36,508	191	1.12	214.	6.4
Mobile & Ohio	1,348.79	3007	507,269	376	0.97	365.	12.5
Nashville, Chattanooga & St. Louis	1,766.69	2687	563,696	319	1.27	405.	11.6
New Orleans & Northeastern	322.10	2753	121,040	376	1.36	511.	13.6
New Orleans Great Northern	280.40	3282	71,816	256	1.25	320.	7.8
Norfolk Southern	1,153.43	2659	320,049	277	0.85	235.	10.4
Northern Alabama	134.51	3139	67,157	499	.91	454.	15.9
Seaboard Air Line	5,470.96	3064	1,335,039	244	1.16	283.	8.0
Southern Ry.	9,037.53	3171	3,506,397	388	1.19	462.	12.2
Tennessee Central	358.01	3098	167,078	467	0.70	327.	15.1
Western Ry. of Alabama	183.58	3081	50,694	276	1.48	408.	9.0
Yazoo & Mississippi Valley	2,411.51	2936	612,704	254	1.29	328.	8.7
NORTHWESTERN REGION:							
Chicago & North Western	12,384.75	2946	2,520,345	204	1.22	249.	6.9
Chicago Great Western	1,953.14	2878	431,738	221	1.14	252.	7.7
Chicago, Milwaukee, St.Paul & Pacific	15,446.35	2804	4,403,713	285	1.00	285.	10.2
Chicago, St. Paul, Minpls. & Omaha	2,539.47	2737	671,957	265	1.18	313.	9.7
Duluth & Iron Range	492.10	3131	151,744	308	1.29	397.	9.8
Duluth, Missabe & Northern	721.03	3050	165,089	229	1.81	414.	7.5
Duluth, So.Shore & Atlantic	730.32	2914	247,967	340	.70	238.	11.7
Duluth, Winnipeg & Pacific	214.09	2914	93,172	435	.67	291.	14.9
Great Northern	10,059.77	3117	2,071,460	206	1.02	210.	6.6
Green Bay & Western	283.22	2783	93,728	331	.79	261.	11.9
Lake Superior & Ishpeming	226.90	3000	49,700	219	.65	142.	7.3
Minneapolis & St. Louis	1,811.51	3014	394,955	218	1.28	279.	7.2
Minpls., St. Paul & S. S. Marie	5,256.04	2924	1,421,198	270	.86	232.	9.2
Northern Pacific	9,722.40	2713	1,537,600	158	1.12	177.	5.8
Oregon-Washington R.R.& Nav.Co.	2,251.35	2912	572,570	254	.82	208.	8.7
Spokane International	199.89	2738	69,237	346	.52	180.	12.7
Spokane, Portland & Seattle	664.07	2879	211,130	318	.86	273.	11.0

TABLE 3

WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES

Calender Year Ended Dec. 31,1927

Note: All figures are exclusive of Bridge and Switch Ties.

Road	Miles of Maintained Track Occupied by Wooden Cross Ties (Col.8-Table A)	Average Number of Wooden Cross Ties per Mile of Maintained Track	Total Number of Wooden Cross Ties Renewed 1927	Average Number of Wooden Cross Ties Renewed per Mile of Maintained Track	Weighted Average Cost per Wooden Cross Tie	Average Cost of Wooden Cross Tie Renewals Per Mile of Maintained Track	Average Percentage of Wooden Cross Tie Renewals
1	2	3	4	5	6	7	8
CENTRAL WESTERN REGION:							
Atchison, Topeka & Santa Fe	14,686.93	3037	2,014,060	137	$ 1.45	$ 199.	4.5
Bingham & Garfield	42.00	2788	14,039	334	1.84	615.	12.0
Chicago & Alton	1,631.43	3001	448,808	275	1.20	330.	9.2
Chicago, Burlington & Quincy	12,885.54	3088	2,143,538	166	1.31	217.	5.4
Chicago, Rock Island & Gulf	568.46	3055	152,237	268	1.32	354.	8.8
Chicago, Rock Island & Pacific	10,025.80	2910	1,485,948	148	1.16	172.	5.1
Colorado & Southern	1,269.63	3026	245,471	153	1.40	270.	6.4
Denver & Rio Grande Western	3,599.00	2972	788,575	219	1.16	254.	7.4
Denver & Salt Lake	315.44	3000	97,302	308	1.48	456.	10.3
Fort Worth & Denver City	643.94	2949	193,597	301	1.48	445.	10.2
Los Angeles & Salt Lake	1,482.80	2787	214,560	145	1.36	197.	5.2
Nevada Northern	190.26	2880	38,463	202	1.03	208.	7.0
Northwestern Pacific	581.07	2957	143,339	247	.81	200.	8.3
Oregon Short Line	3,331.88	2788	666,592	200	1.15	230.	7.2
Panhandle & Santa Fe	1,309.51	3040	166,488	127	1.52	193.	4.2
Quincy, Omaha & Kansas City	266.46	3140	67,823	255	1.35	344.	8.1
St. Joseph & Grand Island	327.10	2791	71,650	219	1.45	318.	7.8
Southern Pacific	12,463.39	2926	2,803,046	225	1.44	324.	7.7
Toledo, Peoria & Western	282.38	3000	83,132	294	1.22	359.	9.8
Union Pacific	5,878.00	2822	1,172,856	200	1.17	234.	7.1
Utah Ry.	108.70	2852	11,261	104	1.21	126.	3.6
Western Pacific	1,302.22	2831	535,319	411	.85	349.	14.5
SOUTHWESTERN REGION:							
Beaumont, Sour Lake & Western	104.66	2991	30,390	290	1.36	394.	9.7
Fort Smith & Western	234.712	3129	72,939	311	.71	221.	9.9
Fort Worth & Rio Grande	245.36	3168	68,356	279	1.14	318.	8.8
Gulf, Colorado & Santa Fe	2,465.36	3483	319,661	130	1.32	172.	3.7
International-Great Northern	1,523.50	2867	411,696	270	1.18	319.	9.4
Kansas City, Mexico & Orient	310.46	2873	180,583	582	1.35	786.	20.2
Kansas City, Mexico & Orient of Tex.	544.18	2760	447,062	822	.95	781.	29.8
Kansas City Southern	1,152.10	3133	163,725	142	1.41	200.	4.5
Kansas, Oklahoma & Gulf	370.56	3141	212,326	573	1.56	894.	18.2
Louisiana & Arkansas	343.69	3001	96,779	282	.99	279.	9.4
Louisiana Ry. & Nav. Co.	435.03	3200	101,764	234	.99	232.	7.3
Louisiana Ry. & Nav. Co. of Tex.	228.52	3022	59,784	262	.96	252.	8.7
Midland Valley	436.30	3099	123,112	282	1.45	409.	9.1
Missouri & North Arkansas	383.191	2972	149,444	390	.69	269.	13.1
Missouri-Kansas-Texas	2,471.41	2954	618,021	250	1.28	320.	8.5
Missouri-Kansas-Texas of Tex.	1,847.39	2926	423,311	229	1.29	295.	7.8
Missouri Pacific	9,817.13	2882	2,623,207	267	1.06	283.	9.3

TABLE B

WOODEN CROSS TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended Dec. 31, 1927.

Note: All figures are exclusive of Bridge and Switch Ties.

Road	Miles of Maintained Track Occupied by Wooden Cross Ties (Col.8 - Table A)	Average Number of Wooden Cross Ties per Mile of Maintained Track	Total Number of Wooden Cross Ties Renewed 1927	Average Number of Wooden Cross Ties Renewed per Mile of Maintained Track	Weighted Average Cost per Wooden Cross Tie	Average Cost of Wooden Cross Tie Renewals Per Mile of Maintained Track	Average Percentage of Wooden Cross Tie Renewals
1	2	3	4	5	6	7	8
SOUTHWESTERN REGION (Cont'd)							
New Orleans, Texas & Mexico	223.78	3061	67,146	300	$ 1.34	$ 402.	9.8
St. Louis, Brownsville & Mexico	689.66	3059	276,657	401	1.26	505.	13.1
St. Louis-San Francisco	6,709.146	3096	1,234,390	184	1.05	193.	5.9
St. Louis, San Francisco & Texas	108.20	3168	38,913	360	1.10	396.	11.4
St. Louis Southwestern	1,088.62	2836	382,018	351	1.40	491.	12.4
St. Louis Southwestern of Tex.	1,031.22	2893	240,604	233	1.43	333.	8.1
San Antonio, Uvalde & Gulf	348.42	2807	61,567	177	1.36	241.	6.3
Texarkana & Fort Smith	159.02	3097	14,295	90	1.92	173.	2.9
Texas & New Orleans	6,300.66	2811	1,260,368	200	1.48	296.	7.1
Texas & Pacific	2,454.03	3148	963,795	393	1.26	495.	12.5
Texas Mexican	199.821	2880	68,771	344	1.62	557.	12.0
Trinity & Brazos Valley	356.02	3133	68,884	193	1.04	201.	6.2
Wichita Valley	309.43	2880	46,051	149	1.27	189.	5.2
Galveston, Harrisburg & San Antonio a	2,825.01	2590	93,453	33	1.73	57.	1.3
Houston & Texas Central a	1,161.83	2684	29,183	25	1.71	43.	.9
Houston East & West Texas a	258.17	2542	6,713	26	1.39	36.	1.0
Louisiana Western a	288.22	2346	9,458	33	1.55	51.	1.4
Morgan's La.& Tex. R.R. & S.S. Co. a	669.42	2311	27,876	42	1.28	54.	1.8

a Two months ended Feb. 28, 1927.

Col. 3 derived by dividing Col.9 Table A by Col.8 of same table

Col. 4 is total of columns 2 and 4 of Table A.

Col. 5 derived by dividing the totals of Cols. 2 and 4 of Table A by Col.8 of same table.

Col. 6 is the weighted average of costs shown in columns 3 and 5 of Table A.

Appendix I

(11) PROPER SIZE OF HOLES FOR PREBORING

R. S. Belcher, Chairman, Sub-Committee; F. T. Becket, E. E. Chapman, J. S. Ruff, W. W. Wysor.

A canvass of railroads two years ago by this Committee indicated that there was some variation in practice as to size of holes bored for certain sizes of spikes. It was, however, found that most railroads bore $\frac{1}{16}$ inch smaller than the spike in hardwood ties and $\frac{1}{8}$ inch smaller in softwood ties, although in the case of roads using a $\frac{5}{8}$-inch cut spike in hardwood ties the practice was almost evenly divided as between the $\frac{1}{16}$-inch smaller and $\frac{1}{8}$-inch smaller. All roads boring for screw spikes bore the hole the same size as the core of the spike with one exception and this road used $\frac{1}{32}$ inch less than the core of the spike in pine ties. Most of the roads bore entirely through the ties.

Last year the report of this Committee included a report of tests made by E. E. Chapman, Engineer of Tests, Atchison, Topeka & Santa Fe Railway. The object of these tests was to ascertain the most efficient size of hole for $\frac{9}{16}$-inch and $\frac{5}{8}$-inch cut spikes, and covered more than 5000 individual tests in ties of ten kinds of wood. Each kind was tested untreated, creosote treated, and creosote-petroleum treated. This report is found on page 209 of the 1928 Proceedings.

Conclusions

1. Because it is very difficult to make chisel-pointed spikes follow $\frac{1}{4}$-inch and $\frac{3}{8}$-inch holes, your Committee conclude these sizes are too small for practical use.

2. In hardwood ties, using $\frac{9}{16}$-inch by 6-inch cut spikes, the $\frac{7}{16}$-inch holes give greatest resistance to vertical pull; using $\frac{5}{8}$-inch by 6-inch cut spikes, $\frac{1}{2}$-inch holes give greatest resistance.

In softwood ties, the $\frac{7}{16}$-inch holes give greatest resistance to vertical pull with both $\frac{9}{16}$-inch by 6-inch and $\frac{5}{8}$-inch by 6-inch cut spikes.

Comparing untreated, creosote treated and creosoted-petroleum treated ties, the resistance to vertical pull is greatest in the untreated and least in the creosote-petroleum treated.

In all woods tested, the load required to start the spike was the maximum load.

3. In hardwood ties, using $\frac{9}{16}$-inch by 6-inch cut spikes, the $\frac{9}{16}$-inch holes give greatest resistance to horizontal thrust; using $\frac{5}{8}$-inch by 6-inch cut spikes, the $\frac{5}{8}$-inch holes give greatest resistance.

In softwood ties, using $\frac{9}{16}$-inch by 6-inch cut spikes, the $\frac{9}{16}$-inch holes give greatest resistance to horizontal thrust; using $\frac{5}{8}$-inch by 6-inch cut spikes, there is little difference between the $\frac{1}{2}$-inch, $\frac{9}{16}$-inch and $\frac{5}{8}$-inch holes.

4. Disturbance of the wood fibers is much less where spikes are driven in holes $\frac{7}{16}$ inch in diameter or larger. In general there is the least damage to the fiber when the largest size holes are used.

5. Spike holes should be bored entirely through the ties except in the case of ties for use in direct current electric lines having covered track. Under such conditions it has been found that spikes corrode badly due to electrolysis when the spike holes are bored entirely through the ties.

6. The chisel-pointed spike is not altogether satisfactory for driving into bored holes because of the tendency of the sharp corners to lead the spike away from the hole. The Committee is of the opinion that the type of spike point for driving into bored holes should have further study.

7. The Committee is of the opinion that at least equal weight should be given resistance to horizontal thrust as compared to resistance to vertical pull, when considering this question. Consideration should also be given to the fact that disturbance of the wood fibers is least in the larger sized holes.

Recommendations

1. That ½-inch holes be bored in hardwood ties for $\frac{9}{16}$-inch cut spikes.
2. That $\frac{9}{16}$-inch holes be bored in hardwood ties for ⅝-inch cut spikes.
3. That $\frac{7}{16}$-inch holes be bored in softwood ties for $\frac{9}{16}$-inch cut spikes.
4. That ½-inch holes be bored in softwood ties for ⅝-inch cut spikes

REPORT OF COMMITTEE XX—UNIFORM GENERAL CONTRACT FORMS

J. C. IRWIN, *Chairman;*
C. FRANK ALLEN,
H. E. BARLOW,
W. H. BRAMELD,
B. S. DICKERSON,
W. D. FAUCETTE,
F. H. FECHTIG,
J. S. LILLIE,
S. L. MAPES,
A. A. MILLER,
O. K. MORGAN,
E. L. TAYLOR, *Vice-Chairman;*
F. L. NICHOLSON,
C. B. NIEHAUS,
W. G. NUSZ,
H. A. PALMER,
CHARLES SILLIMAN,
W. D. SIMPSON,
HUNTINGTON SMITH,
C. A. WILSON,
JOHN WORLEY,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of the Manual (Appendix A).

(2) Form of Agreement for Joint Ownership, Use and Management of a Terminal Project, collaborating with Committee XIV—Yards and Terminals (Appendix C).

(3) Form of Cost-Plus Percentage and Fixed Fee in Construction Contracts (Appendix A).

(4) Form of Agreement for Purchase of Electrical Energy in Large Volume (such as required for traction purposes), collaborating with Committee XVIII—Electricity (Appendix B).

(5) Form of Application for Industry Track (Appendix C).

(6) Form of Agreement for Use of Railway Property for Public Highways (Appendix B).

(7) Form of Agreement for Wire Line Crossings, collaborating with Committee XVIII—Electricity (Appendix B).

Action Recommended

1. That no changes be made in the Manual at this time.

2. That the information on Form of Agreement for Joint Ownership, Use and Management of a Terminal Project as printed in Appendix C, be accepted as a progress report and that the subject be continued under the title of "Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project."

3. That the Form of Cost Plus Percentage Construction Contract, as printed in Appendix A, be approved for publication in the Manual, and that further consideration be given by this Committee to the treatment of Cost-Plus Fixed Fee Construction Contracts.

Bulletin 311, November, 1928.

4. That the subject "Form of Agreement for Purchase of Electrical Energy in Large Volume" be continued in the Outline of Work for the ensuing year.

5. That the Form of Application for Industry Track as printed in Appendix C be received as information and for discussion.

6. That the subject "Form of Agreement for Use of Railway Property for Public Highways" be eliminated from the Outline of Work, as this Committee's investigation indicates that it is unsuitable for standardization by this Association.

However, this Committee refers to the form under this title which it prepared and which was printed in Bulletin 293, January, 1927, pages 463 to 466, which may be helpful to those interested in such a form, but which this Committee does not endorse as a standard for the reason above given.

7. That the Form of Agreement for Wire Line Crossings as printed in Appendix B be received as information and discussion.

Recommendations for Future Work

1. Revision of the Manual.
2. Continue study of Cost-Plus Fixed Fee in Construction Contracts.
3. Continue study of Form of Agreement for the Purchase of Electrical Energy in Large Volume (such as required for traction purposes), collaborating with Committee XVIII—Electricity.
4. Continue study of Form of Agreement for Wire Line Crossings, collaborating with Committee XVIII—Electricity.
5. Continue study of Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project, collaborating with Committee XIV—Yards and Terminals.
6. Continue study of Form of Application for Industry Track.
7. Outline of work for ensuing year.

Respectfully submitted,

The Committee on Uniform General Contract Forms,

J. C. Irwin, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

(3) CONTINUE STUDY OF FORM OF COST-PLUS PERCENTAGE AND FIXED FEE IN CONSTRUCTION CONTRACTS

F. L. Nicholson, Chairman, Sub-Committee; C. Frank Allen, W. D. Faucette, F. H. Fechtig, O. K. Morgan, C. B. Niehaus, Charles Silliman.

(1) Your Committee has no Revisions of the Manual to recommend at this time.

(3) The Sub-Committee handling the preparation of a Cost-Plus Percentage Construction Contract Form reported progress in the study of this subject at the 1927 Convention, and at the 1928 Convention a contract form was submitted for information and discussion, since which time intensive study has been given this subject by the Committee. Legal advice has been obtained and considered in the preparation of all provisions involving points of law or legal interpretation.

The Contract Form now submitted has been drafted with painstaking care; sections appearing in the General Form of Construction Contract as revised in 1927 have been used wherever applicable.

The Form of Cost-Plus Percentage Contract is submitted for your consideration.

FORM OF COST-PLUS PERCENTAGE CONSTRUCTION CONTRACT

This Contract, Made this the .... day of .... in the Year ...., by and between .... hereinafter called the Contractor, and .... hereinafter called the Company.

Witnesseth, That, in consideration of the covenants and agreements herein contained, to be performed by the parties hereto, and of the payments hereinafter agreed to be made, it is mutually agreed as follows:

The Contractor shall furnish all of the materials, superintendence, labor, tools, equipment and transportation, except as hereinafter specified, and shall execute, construct and finish, in an expeditious, substantial and workmanlike manner, to the satisfaction and acceptance of the Chief Engineer of the Company, all of the work required for ....
....
....
....
....
in accordance with the plans furnished or to be furnished during the progress of the work and identified by the signature of the Engineer, together with the specifications hereby included and the instructions hereafter to be given by the Engineer.

The work covered by this contract shall be commenced on or before the .... day of ...., 19......, and shall be completed on or before the .... day of ...., 19......

And in consideration of the completion of the work described herein and the fulfillment of all stipulations of this contract to the satisfaction and acceptance of the Chief Engineer of the Company, the Company shall pay, or cause to be paid, to the Contractor, the amount due to the Contractor based on the cost hereinafter defined, plus the fee hereinafter specified.

1. Intent of Plans and Specifications

All work that may be called for in the specifications and not shown on the plans, or shown on the plans and not called for in the specifications, shall be executed and furnished by the Contractor as if described in both these ways; and should any work or material be required which is not detailed in the specifications or on the plans, either directly or indirectly, but which is nevertheless necessary for the proper carrying out of the intent thereof, the Contractor is to understand the same to be implied and required, and shall perform all such work and furnish any such material as fully as if they were particularly detailed or described.

2. Contractor's Understanding

It is understood and agreed that the Contractor has, by careful examination, satisfied himself as to the nature and location of the work, the conformation of the ground, the character, quality and quantity of the materials to be encountered, the character of equipment and facilities needed preliminary to and during the prosecution of the work, the general and local conditions, and all other matters which can in any way affect the work under this contract. No verbal agreement or conversation with any officer, agent or employee of the Company, either before or after the execution of this contract, shall affect or modify any of the terms or obligations herein contained.

3. Land for Use of Contractor

The Company shall provide the land upon which the work under this contract is to be done, and will, so far as it can conveniently do so, permit the Contractor to use so much of its land as is required for temporary construction purposes and the storage of materials, together with the right of access to same, and in addition thereto, such lands not owned by the Company as may be, in the opinion of the Engineer, necessary for such purposes.

4. Consent to Transfer

The Contractor shall not let or transfer this contract or any part thereof (except for the furnishing and delivery of material) without consent of the Chief Engineer, given in writing. Such consent does not release or relieve the Contractor from any of his obligations and liabilities under the contract.

5. Sub-Contractor

The Contractor shall procure and submit to the Chief Engineer competitive proposals from sub-contractors satisfactory to the Engineer, for items of work to be sub-contracted. From these proposals the Chief Engineer shall select the sub-contractors to perform the work.

The Contractor shall enter into a contract with each sub-contractor so selected in a form satisfactory to the Chief Engineer.

Sub-contractors shall deal directly with the Contractor who shall be responsible for the execution of the work in accordance with the terms of this contract.

6. Engineer and Chief Engineer

Wherever in this contract the word Engineer is used, it shall be understood as referring to the Chief Engineer of the Company, acting personally or through an assistant duly authorized in writing for such act by the Chief Engineer, and wherever the words Chief Engineer are used it shall be understood as referring to the Chief Engineer in person, and not to any assistant engineer.

7. Power of Engineer

The Engineer shall have power to reject or condemn all work or material which does not conform to this contract; to direct the application of forces to any portion of the work which, in his judgment, requires it; to order the force increased or diminished, and to decide questions which arise between the parties relative to the execution of the work.

8. Waiver

It is expressly understood and agreed that any waiver on the part of the Company or the Engineer, of any term, provision or covenant of this contract, shall not constitute a precedent, nor bind the Company or the Engineer, to any further waiver of the terms, provisions or covenants of this contract.

9. Adjustment of Dispute

All questions or controversies which may arise between the Contractor and the Company, under or in reference to this contract, shall be subject to the decision of the Chief Engineer, and his decision shall be final and conclusive upon both parties.

10. Permits

Permits of a temporary nature necessary for the prosecution of the work shall be secured and paid for by the Contractor as a part of the cost of the work.

Permits for permanent structures or permanent changes in existing facilities shall be secured and paid for by the Company, on which expense the Contractor shall receive no fee.

11. Insurance

The Contractor shall secure in the name of the Company, policies of insurance in amount, form and companies, satisfactory to the Chief Engineer, upon such structures and material as shall be specified by the latter, payable to the Company for the benefit of the Contractor or the Company as the Chief Engineer shall find their interests to appear.

12. Workmen's Compensation Insurance

The Contractor shall comply with all the laws of the State wherein the contract is to be performed, arising under any "Workmen's Compensation Act," and shall at all times carry and pay the premiums on all policies of insurance required by the laws of the State wherein the work is being performed, under any "Workmen's Compensation Act," so that the Company shall be fully protected from any and all claims for damages for personal injury, including death, which may arise from operations under this contract, whether such operations be by himself, or by any subcontractor, or anyone directly or indirectly employed by either of them. Certificates of such insurance shall be filed with the Chief Engineer, if he so requires, and shall be subject to his approval for adequacy of protection.

13. Indemnity

The Contractor shall furnish indemnity insurance in amount, form and substance satisfactory and acceptable to the Company, which insurance shall indemnify and save harmless the Company from and against all losses and all claims, demands, payments, suits, actions, recoveries and judgments of every nature and description made, brought or recovered against the Company by reason of any act or omission of the Contractor, his agents or employees, in the execution of the work, or in guarding the same.

14. Superintendence

The Contractor shall constantly superintend all of the work embraced in this contract, in person or by a duly authorized representative acceptable to the Company.

15. Notice—How Served

Any notice to be given by the Company to the Contractor under this contract shall be deemed to be served if the same be delivered to the person in charge of the office used by the Contractor, or to his representative at or near the work, or deposited in the postoffice, postpaid, addressed to the Contractor at his last known place of business.

16. Protection

The Contractor shall furnish and maintain passageways, guard fences and lights and such other means of protection to persons and property as may be necessary or required by local conditions, laws or ordinances.

17. Timely Demand for Points and Instructions

The Contractor shall provide reasonable and necessary opportunities and facilities for setting points and making measurements. He shall not proceed until he has made timely demand upon the Engineer for, and has received from him, such points and instructions as may be necessary as the work progresses. The work shall be done in strict conformity with such points and instructions.

18. Preservation of Stakes

The Contractor shall carefully preserve bench marks, reference points and stakes, and in case of wilful or careless destruction, he will be charged with the resulting expense and shall be responsible for any mistakes that may be caused by their unnecessary loss or disturbance.

19. Report Errors and Discrepancies

If the Contractor, in the course of the work, finds any discrepancy between the plans and the physical conditions of the locality, or any errors or omissions in plans or in the layout as given by points and instructions, it shall be his duty to immediately inform the Engineer, in writing, and the Engineer shall promptly verify the same.

20. Inspection

All work and material shall be at all times open to the inspection, acceptance or rejection of the Engineer or his authorized representative. The Contractor shall give the Engineer reasonable notice of starting any new work and shall provide reasonable and necessary facilities for inspection even to the extent of taking out portions of finished work. No work shall be done at night without the previous approval of the Engineer.

21. Tests of Materials

The Contractor shall furnish, if requested by the Engineer, samples of any materials to be used in the work, for such tests as may be desired; the materials thereafter furnished shall be in strict accordance with approved samples.

22. Fitness, Condition and Value of Plant

The tools and equipment furnished by the Contractor shall be in a first class workable condition when received on the work and shall be subject to the approval of the Engineer as to their fitness and condition for the work to be performed.

The Chief Engineer shall, at the time of receipt, fix a fair valuation for each of such tools and equipment.

23. Rentals

The rentals of tools and equipment, not purchased for the work, and not including hand tools owned by the workmen, shall be in accordance with the schedule of tools and equipment and rates hereto attached and made a part of this contract. The period of rental for any article shall extend from the date it is placed in operation on the work, and shall be continuous, including Sundays and holidays, until such time as the Engineer shall notify the Contractor, in writing, that it is no longer needed.

24. Purchase of Material

The Contractor shall prepare necessary bills of materials required for the work and shall make purchases and contracts in his own name. Purchases exceeding .... Dollars in cost shall be purchased from the lowest bid submitted by not less than three reputable dealers, provided that under such bid the materials of quantity required and quality specified can be furnished without delay to the Contractor.

The Contractor shall, before purchasing, tabulate and submit such bids to the Chief Engineer, with recommendation for approval.

The Chief Engineer, if he so desires, may secure bids for materials, and such bids shall be given the same consideration as if secured by the Contractor.

25. Routing Shipments

All shipments in connection with this contract shall be routed as may be directed by the Company.

26. Work Adjacent to Railway or Other Property

Wherever the work embraced in this contract is near the tracks, structures or buildings of the Company or of other railways, or persons, the Contractor shall use proper care and vigilance to avoid injury to persons or property. The work shall be so conducted as not to interfere with the movement of trains or other operations of the railway; or, if in any case such interference be necessary, the Contractor shall not proceed until he has first obtained specific authority and directions therefor from the proper designated officer of the Company and has the approval of the Engineer.

27. Rights of Various Interests

Wherever work being done by Company forces or by other contractors is contiguous to work covered by this contract, the respective rights of the various interests involved shall be established by the Engineer, to secure the completion of the various portions of the work in general harmony.

28. Order and Discipline

The Contractor shall at all times enforce strict discipline and good order among his employees, and any employee of the Contractor who shall appear to be incompetent, disorderly or intemperate, or in any other way disqualified for or unfaithful to the work entrusted to him, shall be discharged immediately on the request of the Engineer, and he shall not again be employed on the work without the Engineer's written consent.

29. Contractor Not to Hire Company's Employees

The Contractor shall not employ or hire any of the Company's employees without the permission of the Engineer.

30. Order of Completion—Use of Completed Portions

The Contractor shall complete any portion or portions of the work in such order of time as the Engineer may require. The Company shall have the right to take possession of and use any completed or partially completed portions of the work, notwithstanding the time for completing the entire work or such portions may not have expired; but such taking possession and use shall not be deemed an acceptance of the work so taken or used or any part thereof.

31. Changes

The Company shall have the right to make any changes that may be hereafter determined upon, in the nature or dimensions of the work, either before or after its commencement, and such changes shall in no way affect or void the obligations of this contract, nor shall such changes constitute a claim for damages or for anticipated profits.

32. Unavoidable Delays—Extension of Time on Parts of Work

If the Contractor shall be delayed in the performance of the work from any cause beyond his control, he may, upon written application to the Chief Engineer within three (3) days of such delay, be granted such extension of time as the Chief Engineer shall deem equitable and just.

33. Suspension of Work

The Company may at any time stop the work or any part thereof by giving .... days' notice, in writing, to the Contractor. The work shall be resumed by the Contractor within ten (10) days after the date fixed in a written notice from the Company to the Contractor so to do. The Company will pay the Contractor for the expense of men and equipment necessarily retained during the interval of suspension; provided, the Contractor can show that it was not reasonably practicable to move the men and equipment to other points at which they could have been employed. If the Company does not give notice in writing to the Contractor to resume work at a date within .... days of the date fixed in the written notice to suspend, then the Contractor may abandon that portion of the work so suspended and he will be entitled to payment, under the terms of this contract, for work done on such portion so abandoned.

34. Annulment Without Fault of Contractor

The Company shall have the right at any time, for reasons which appear good to it, to annul this contract upon giving notice, in writing, to the Contractor, in which event the Contractor shall be entitled to payment, under the terms of this contract, for work done up to the time of such annulment, together with the actual cost to the Contractor of relief from liability with respect to commitments actually entered into prior to date of notice of such annulment. The Contractor shall make no voluntary settlement with any party to whom commitment is due without the approval of the Chief Engineer.

The Contractor shall make no claim for damages of any kind or for fee or anticipated profits upon work not actually performed.

35. Failure of Performance by Contractor

(a) If the Chief Engineer of the Company shall at any time be of the opinion that the Contractor is not progressing with the work as fast as necessary to insure its completion within the time and as required by the contract, or is otherwise violating any of the provisions of this contract, the Chief Engineer, in behalf of the Company, shall have the power, and it shall be his duty, to notify the Contractor in writing to proceed more rapidly with the work, or otherwise to comply with the provisions of this contract.

(b) If on the expiration of ten (10) days after the serving of such written notice upon the Contractor, the Contractor shall continue to neglect the work and shall fail to satisfy the Engineer of his efforts, ability and intentions to remedy the specified deficiencies, the Company may terminate the employment of the Contractor or may take possession of any part of the work and of all materials, tools and equipment thereon, and employ such means as, in the Engineer's judgment, may be necessary to finish the work, in this case the Contractor shall be paid for the work done by him. If the Company should utilize the tools and equipment of the Contractor for the completion of the work, the Contractor shall be paid the rental charges as provided under this contract.

36. Removal of Equipment

In case of annulment of this contract before completion from any cause whatever, the Contractor, if notified to do so by the Company, shall promptly remove any part or all of his tools and equipment from the property of the Company, failing which the Company shall have the right to move such tools and equipment.

37. Settlement for Wages

Whenever, in the opinion of the Chief Engineer, it may be necessary for the progress of the work to secure to any of the employees engaged on the work under this contract any wages which may then be due them, the Company is hereby authorized to pay said employees the amount due them or any lesser amount, and the amount so paid them, as shown by their receipts, shall be deducted from any moneys that may be or become payable to the Contractor.

38. Accounts and Records

The Contractor shall keep accurate and detailed accounts of all disbursements in form satisfactory to the Chief Engineer, and shall give the Engineer access at any or all times to the Contractor's books appertaining to such disbursements. If the Chief Engineer desires, he shall have the right to place competent employees in any position of accounting or checking, in which event such employees shall perform their respective duties in accordance with the method for handling the work adopted by the Contractor.

39. Costs to Which the Fee to the Contractor Shall Be Added

(a) Labor.—The labor cost shall be the actual payroll costs for all fieldmen or temporary field office force employed by the Contractor in connection with and at the work. It shall include the cost of loading tools and equipment for shipment to the site of the work and unloading at the site, and the cost, upon completion of the work, of loading the same for shipment, and unloading at the Contractor's store yard or other approved destination. The rates paid shall not be higher than the standard rates paid for similar service in the locality of the work, without the prior written approval of the Chief Engineer.

The labor cost shall not include any part of the Contractor's general expenses or the salaries of his officers, or of office employees who do not devote their entire time to the work covered by this contract, unless specifically authorized by the Chief Engineer.

(b) Materials.—The material cost shall be the actual costs to the Contractor of materials entering into the work covered by this contract, as evidenced by the correct receipted bills rendered by the dealer to the Contractor and approved by the Engineer.

Any trade discount, rebate or commission granted to the Contractor or any employees shall be credited to the cost, except that cash discounts for prompt payments are for the benefit of the Contractor.

The cost of materials and tools properly purchased for the work but not actually incorporated therein shall be the net first cost as above defined less the sale price or market value at the termination of the work, as approved by the Engineer.

(c) Sub-Contracts.—The cost of sub-contracts shall be the actual cost shown by original bills and payrolls, rendered by the Sub-Contractor to the Contractor and approved by the Engineer.

(d) Running Repairs to Plant.—The cost of running repairs shall be the material and labor costs.

(e) Transportation.—The cost of transportation shall include the costs to the Contractor of transportation of materials over lines other than that of the Company and of labor properly brought from a distance with the approval of the Engineer, together with the necessary traveling expenses properly incurred, in connection with the work, and paid by the Contractor.

(f) Bonds and Insurance.—The cost of premiums on bonds and insurance required, if paid by the Contractor.

(g) Telegraph and Telephone Service.—The cost of telegraph and telephone service connected with the work, if paid by the Contractor.

(h) Permits.—The cost of permits secured and paid for by the Contractor.

40. Costs to Which the Fee to the Contractor Shall Not Be Added

(a) Transportation.—Transportation charges on tools and equipment of the Contractor to the site of the work and return from the site of the work to the store yard of the Contractor or other agreed destination. Tranpsoration charges over the lines of the Company.

(b) Demurrage.—Demurrage on cars.

(c) Work Train.—The cost of work train service furnished by the Company.

(d) Watchmen.—The cost of watchmen and flagmen furnished by the Company.

(e) Plant Rental.—Fixed prices for rental of tools and equipment.

41. Service to Be Furnished by the Contractor, the Cost of Which Is Paid for in the Fee to the Contractor

(a) The services of the Contractor's executive officers, who shall direct and oversee the work.

(b) The services of the Contractor's Purchasing Department, which shall make all major purchases.

(c) The services of the Contractor's employment and personnel departments, who will supervise the labor conditions pertaining to the work.

(d) The services of the Contractor's home office accounting and cost accounting department, which will establish proper systems of accounting for the work and accumulate the detail figures for final vouchering and reporting under the rules of the Interstate Commerce Commission.

(e) All general expenses of the Contractor's general offices, which shall include rent, light, heat, postage, service of stenographers, clerks and like costs.

(f) In general, all items which constitute overhead costs of the Contractor and which items are not properly a part of the direct costs of the work.

42. Fee (Percentage)

The Contractor shall be paid in addition to the cost of the work as herein defined .... per cent of such cost, as his fee for services rendered.

43. Failure to Make Payments

Failure by the Company to make payments at the times provided in this contract, shall give the Contractor the right to suspend work until payment is made; or at his option, after .... days' notice in writing, should the Company continue to default, to terminate this contract and recover the cost of all work done and materials provided. The Company's failure to make payments at the times provided shall be a bar to any claim by the Company against the Contractor for delay in completion of the work, due to such suspension for failure to pay.

44. Payments

Between the first and seventh of each month the Contractor shall present to the Chief Engineer a statement of the cost of the work for the preceding month with such payrolls, receipts and vouchers as the Chief

Engineer may require, together with a statement of moneys due and unpaid in connection with the contract. The Chief Engineer shall promptly check the statement of the costs, including the rental of tools and equipment for the period covered by the statement and the correct amount due together with the fee earned shall be paid to the Contractor by the Company, on or about the .... of the current month.

Upon the completion and acceptance of the work, and satisfactory evidence of the payment by the Contractor of all obligations accruing under the contract for which the Company may be legally liable, the Chief Engineer shall promptly certify the final amount due, including the fee provided under this contract, and payment shall be made by the Company to the Contractor within thirty (30) days after the date of the Chief Engineer's certificate, giving the final amount due.

This contract shall inure to the benefit of and be binding upon the legal representatives and successors of the parties respectively.

In Witness Whereof, The parties hereto have executed this contract, in ...., the day and year first above written.

....
(Contractor)

Witness:
.... By..............................

....
(Company)

Attest:
.... By..............................

The Committee recommends the adoption of this form as recommended practice and that it be printed in the Manual.

Your Committee has given thought to the use of this form for Cost-Plus Percentage Contract with fixed maximum and also its use under a Fixed Fee basis. The Committee is not ready to report on these methods but expects to do so next year.

Appendix B

(4) FORM OF AGREEMENT FOR PURCHASE OF ELECTRICAL ENERGY IN LARGE VOLUME (SUCH AS REQUIRED FOR TRACTION PURPOSES)

(6) FORM OF AGREEMENT FOR USE OF RAILWAY PROPERTY FOR PUBLIC HIGHWAYS

(7) FORM OF AGREEMENT FOR WIRE LINE CROSSINGS

E. L. Taylor, Chairman, Sub-Committee; W. H. Brameld, S. L. Mapes, W. G. Nusz, H. A. Palmer, W. D. Simpson, Huntington Smith.

(4) The Committee reports progress with Form of Agreement for Purchase of Electrical Energy in Large Volume and has prepared a draft of such a form which has been submitted to Committee XVIII, the Committee on Electricity, but as the Committee on Electricity has not yet acted on the form Committee XX defers submitting it to the Convention and recommends that it be continued on the list of subjects for the coming year.

(6) At the 1928 Convention Committee XX moved that Form of Agreement for Use of Railway Property for Public Highways be dropped from the outline of work, and upon objection raised by members from the floor, the Chairman, Mr. Irwin, offered to take the subject under consideration again and this was done.

The form is again presented for discussion but the Committee is opposed to its adoption by the Association for the reason that each such agreement is of special character requiring individual consideration and involving legal questions and questions of title so that a uniform form cannot be established.

The Committee recommends that the matter of adopting this form be laid on the table.

(7) The Committee submits as information and for discussion the following Form of Agreement for Wire Line Crossings, and recommends that this be continued on the list of subjects for the coming year and collaborating with Committee XVIII—Electricity:

FORM OF AGREEMENT FOR WIRE LINE CROSSINGS

THIS AGREEMENT, made this .... day of .... by and between ....(hereinafter called the Railway Company) and .... (hereinafter called the Power Company).

WITNESSETH:

WHEREAS, The Power Company desires to construct, maintain and use ....
....
....

over and across the property of the Railway Company, situated ....
.... and substantially as shown
on print hereto attached, made a part hereof, entitled: ....
....

It is mutually agreed as follows:

1. The Railway Company grants permission to the Power Company to construct, maintain and use a certain construction consisting of ....
....
....
....
....
over and across the property of the Railway Company, in accordance with said plan and subject to the requirements of the Railway Company.

2. The Power Company shall pay to the Railway Company as rent the sum of .... Dollars ($................) per year on the .... day of every .... in advance, for the first .... years from the date hereof. At the end of each .... year period from the date hereof the rent for the next succeeding .... year period shall be fixed by agreement between the parties at not less than the rent named for the first .... years.

3. The Power Company shall also pay all taxes upon said construction, or on account of the existence of said construction and shall indemnify the Railway Company from such taxes.

4. The Power Company shall install and maintain said construction to the satisfaction of the Railway Company and under the Railway Company's supervision and direction, and except in case of emergency shall do no work with reference to the maintenance or repair of said construction on the Railway Company's premises except under such supervision and direction and after reasonable notice in writing to the Railway Company.

5. The Power Company shall protect the telegraph, telephone, signal and other circuits on, over or adjacent to property of the Railway Company from electrical or other interference or damage by or because of said construction, and shall construct, maintain and operate said construction in such a manner as will not damage or injuriously affect the use of the telegraph, telephone, signal or other circuits.

6. The Power Company assumes all risk of loss or damage to property of the Power Company on the premises of the Railway Company whether occurring through the negligence of the Railway Company or otherwise.

7. The Power Company shall not in any way or at any time interfere with the safe passage of the Railway Company's trains; and shall indemnify and save harmless the Railway Company from any and all damage, loss or injury, including injury resulting in the death of any person whomsoever, suits, claims or demands resulting from the installation, maintenance or use of said construction, whether caused by the Railway Company's negligence or otherwise.

8. The Power Company shall, at its sole expense, within .... days after receipt of written notice from the Railway Company, remove from the premises of the Railway Company said construction or make such changes therein as may be required by the Railway Company, if such removal or changes shall in the judgment of the Railway Company be needed to protect its operating requirements.

9. The Power Company shall at its sole expense upon discontinuance of use of said construction remove the same from the premises of the Railway Company to the satisfaction of the Railway Company and upon such removal this agreement shall terminate.

10. This grant shall inure to the benefit of and be binding upon the parties hereto, their successors and assigns.

In Witness Whereof, the parties hereto have executed this agreement the day and year first above written.

The .... Company,
By ....
President
(Seal Electric Company)

Witness ....

Attest ....
Secretary.

Witness ....

The .... Company,
By ....
President.
(Seal Railway Company)

Witness ....

Attest ....
Secretary.

Witness ....

Appendix C

(2) FORM OF AGREEMENT FOR JOINT OWNERSHIP, USE AND MANAGEMENT OF A TERMINAL PROJECT ON BASIS OF OUTLINE AS PREPARED BY COMMITTEE XIV—YARDS AND TERMINALS, BULLETIN 284, PAGE 542

(5) FORM OF APPLICATION FOR INDUSTRY TRACK

W. G. Nusz, Chairman, Sub-Committee; H. E. Barlow, B. S. Dickerson, J. S. Lillie, A. A. Miller, C. A. Wilson, John Worley.

(2) FORM OF AGREEMENT FOR JOINT OWNERSHIP, USE AND MANAGEMENT OF A TERMINAL PROJECT

Your Committee collected a large number of contracts covering joint terminals and continued the study of this subject this year. The assignment will be covered by preparation of two forms—one for the "ORGANIZATION OF A JOINT PASSENGER TERMINAL COMPANY" providing for creation of the railway company to operate and maintain it, the construction of the terminal and the method of financing.

The second form, "JOINT PASSENGER TERMINAL COMPANY —OPERATING AGREEMENT," will be made by reference a part of the first but can be fully executed only after the terminal company has been legally formed and authorizes its officers to sign the agreement.

The organization agreement has been prepared and approved by the Committee. The operating agreement has been drafted but is not yet completed. Both form one agreement and must be considered at the same time. After approval by this Committee and complying with our instructions the contracts will be discussed with Committee XIV. It is not possible to present either form of agreement this year, and your Committee recommends that the subject be continued in the outline of work for the coming year.

(5) FORM OF APPLICATION ,FOR INDUSTRY TRACK

Your Committee collected a number of forms, used for this purpose by various railways in the United States and Canada. The information required by the railways is not uniform. A form, requesting information to be supplied by the applicant over his signature and providing for recommendations of the railway officers required to pass on the application, has been prepared by your Committee and is submitted herewith for information and discussion.

APPLICATION FOR INDUSTRY TRACK

1. Full name of applicant ....
   Mail address ....
2. Station or location at which industry track is desired ....
3. Approximate length of industry track .... ft. Capacity needed by applicant .... cars.
4. State if traffic is permanent or temporary and how long industry track will be used ....
   ....
5. Exact name of company or corporation ....
   ....
6. Principal office at ....
7. If a corporation, give state in which incorporated ....
8. Name of President .... Address ....
9. Name of Secretary................ Address ....
10. Name of Local Manager........... Address ....
11. If a firm or co-partnership, give full names and addresses of individual members thereof, and exact name of firm or co-partnership ....
    ....
    ....
    ....
12. If a joint stock company or unincorporated association, give names and addresses of trustees or officers who are authorized to execute a binding contract on behalf of same ....
    ....
13. Amount of paid-up capital stock ....
14. Amount invested in entire business ....
15. Amount invested in existing plant at location of proposed industry track
    ....
16. Amount to be invested in new plant, extensions or rehabilitation of existing plant ....
17. Is plant to be served in operation or a new plant to be constructed......
    ....
18. If plant is in operation, what Railway, if any, serves it ....
    ....
19. If served by a Railway, is it on a private track ....
20. Character of buildings to be constructed and which will be constructed, with approximate size, number of stories of height and kind of material to be used for construction: ....
    ....
    ....
    ....
21. Character of business and kind of product manufactured or handled, with capacity: ....
    ....
    ....
    ....

22. How long has applicant been engaged in this business ....
23. Are any of the parties interested in this plant connected with or interested in any other industry on the ....
Railway Company's lines, if so
Who .... Where ....
What connection ....
24. Is applicant willing to execute lease for land owned by Railway Company, if any is required ....
....
25. Name and address of owner of land on which industry track is to be constructed beyond Railway Company's property.....................
....
26. Is applicant willing to provide at his sole expense any additional right-of-way required for the proposed industry track? ....
....
27. Is applicant willing to secure without cost to the Railway Company, an ordinance acceptable to the Railway Company for any part of said industry track located on a public street or alley? ....
28. If necessary to cross street car or traction tracks, is applicant willing to pay cost and assist in securing authority and proper crossing agreement? ....
29. Is applicant willing, upon notice from the Railway Company of its final approval of the plan for the industry track to deposite with the Railway Company, before any work is started, the amount estimated, it being understood if the actual cost exceeds the estimate, the applicant agrees upon presentation of bill to pay the difference to the Railway Company, but if the actual cost be less than the amount deposited the Railway Company shall promptly return the difference to the applicant? ......
....
30. Kind of fuel used ....
31. Business references are made to ....
....

Signature of applicant ....
Address ....
.........................., 19......

Referred to ....Division Superintendent.

Length industry track required .... ft. Clearance length .... ft.
.... ft. on right-of-way. .... ft. off right-of-way.
Is new turnout required ....
What track does new industry track connect with ....
Is it to be interlocked ...., rail bonded ....
maximum curvature ...., maximum gradient ....,
ascending or descending from main track ....
Give length of track in feet on any public street, road or highway and name of same with name of city, village or township ....
....
....

Corporate name of company owning and number of any street car, interurban or railway tracks crossed ....
....
....

Estimated Cost	To Railway Co.	To Applicant
Total cost of Track—P.S. to end..........	....	....
On Right-of-Way (incl. grading)	....	....
Off Right-of-Way (incl. grading)	....	....
Extra Right-of-Way ...	....	....
Grading .... Cu. Yd.	....	....
Labor	....	....

Construction of industry track is .... recommended.
Estimate in detail and .... copies of plan showing location attached.
Remarks: ....
....

....
Division Engineer.
.... 19.....

Referred to .... Division Freight Agent.
Plan and Operation of proposed industry track is .... practicable.
I recommend the industry track be .... built.
Remarks: ....
....
....

....
Superintendent.
......................., 19.....

Referred to .... { General Superintendent / Traffic Officer }

Approximate revenue paid .... Railway Company by applicant in past twelve months $...............................
Principal points on Railway Company's lines from and to which the products of the applicant move:
At present time:
From .... To ....
From .... To ....
After construction of proposed industry track:
From .... To ....
From .... To ....

State if industry now ships or will ship over other railways, if so, what part of its products and why ....

....

....

Will construction of the industry track result in revenue to this company, now given to other railways ....

....

....

Will construction of industry track result in new business or a division between applicant and any other industry on railway company's lines

....

....

Probable Number of Additional Cars to Be Shipped per Month

		Roadhaul Revenue			Switching Revenue		
Principal Commodities	Origin or Destination	No. Cars	Average Per Car	Total	No. Cars	Average Per Car	Total
Inbound..							
Outbound.							
Total.....							

L.C.L. Freight:
Inbound........................lb., Revenue $........................
Outbound......................lb., Revenue $........................
Is applicant willing to pay entire cost if decided that business offered does not justify any expenditure on part of railway company ....

....

Is applicant willing to pay entire cost of annual maintenance ....
If applicant offers to pay any part, state facts in full ....

....

....

Construction of industry track is .... recommended, applicant to pay cost as follows: ....

....

....

Remarks: ....

....

....

....

....

....
Division Freight Agent.

REPORT OF COMMITTEE XXIII—SHOPS AND LOCOMOTIVE TERMINALS

A. T. Hawk, *Chairman;*
L. P. Kimball, *Vice-Chairman;*
C. N. Bainbridge,
N. Cory,
J. H. Davison,
C. T. Dike,
A. G. Dorland,
E. A. Dougherty,
K. B. Duncan,
C. D. Harding,
C. E. Harris,
G. W. Harris,
W. H. Kirkbride,
L. H. Laffoley,
W. T. Krausch,
H. C. Lorenz,
J. S. McBride,
J. M. Metcalf,
F. E. Morrow,
D. A. Porter,
V. B. W. Poulsen,
W. A. Radspinner,
J. W. Raitt,
John Schofield,
L. K. Sillcox,
H. W. Williams,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents the following report on the respective assignments:

(a) Locomotive Sanding Facilities.

(b) Locomotive Repair Shops.

(c) Methods for the Safe and Convenient Storage of Crude and Fuel Oil.

Action Recommended

1. It is recommended that the report on Locomotive Sanding Facilities be accepted as information; that the heading "Locomotive Sanding Facilities" be inserted in the Manual, and a reference to the text contained in this report added.

2. That the report on Locomotive Repair Shops be accepted as information.

3. That the report on the Safe and Convenient Storage of Crude and Fuel Oil be accepted for publication in the Manual.

Outline of Work for Ensuing Year

1. Revision of Manual.
2. Continue the study of Ashpits.
3. Continue the study of General Layouts and Designs of Car Shops, collaborating with appropriate committee of Division V—Mechanical, A.R.A.
4. Continue the study of Enginehouses, collaborating with appropriate committee of Division V—Mechanical, A.R.A.
5. Continue the study of General Layouts and Designs of Typical Locomotive Repair Shops, collaborating with appropriate committee of Division V—Mechanical, A.R.A.

Respectfully submitted,

Committee on Shops and Locomotive Terminals,

A. T. Hawk, *Chairman.*

Bulletin 311, November, 1928.

Appendix A

(1) LOCOMOTIVE SANDING FACILITIES

L. P. Kimball, Chairman, Sub-Committee; C. N. Bainbridge, J. H. Davison, A. G. Dorland, E. A. Dougherty, C. D. Harding, H. C. Lorenz, J. S. McBride, V. B. W. Poulsen, J. W. Raitt, John Schofield, L. H. Laffoley.

The purpose of the following report is to amplify and supplement the report on Locomotive Coaling Stations which was presented to the 1928 Convention and to furnish data on Locomotive Sanding Facilities which are frequently provided in connection with the construction of coaling stations. When this is done, if sufficient data is given to cover the basic requirements of the sanding facilities, the specifications as adopted for coaling stations can readily be extended to cover same.

These basic requirements are as follows:

(a) Capacity of green sand storage.
(b) Location of green sand storage.
(c) Method of handling green sand.
(d) Location, type and capacity of driers.
(e) Capacity of dry sand storage.
(f) Location of dry sand storage.
(g) Method of handling dry sand.
(h) Location for delivery of dry sand to locomotives.

Sand facilities may be separated into various types and combinations, the most frequently used being as follows:

(1) Ground storage plant either independent or in conjunction with coaling station.
(2) In combination with coaling station a partial gravity plant.
(3) In combination with coaling station a complete gravity plant.
(4) Complete mechanical sand plant either independent of a coaling station or in combination therewith.

Type 1

Plants of this type where ground storage of green sand is the distinguishing feature are becoming less popular with the general use of mechanical coaling stations of concrete construction. The extent of capacity for green sand storage is generally small, although in a few instances large installations of this type have recently been constructed at important terminals. Before deciding to use ground storage, however, even where the quantity to be stored is small, careful consideration should be given to the economy of operation as compared with overhead storage, taking into account the cost of handling from cars to storage and from storage to driers, as well as the cost of construction. Usually sand is unloaded from cars by hand shoveling or by locomotive crane and bin is a long narrow structure parallel to the unloading track. Sand is handled to driers by wheelbarrow and then shoveled into hopper or drier. Compressed air is generally used for the elevation of dry sand to storage compartment either in adjacent coaling station or independent of same. A diagram of the general arrangement above described is shown in Fig. 1.

A modification of this arrangement is possible where steam drier is used by placing drier and sand drum in pit below drier house floor and thereby securing a partial gravity installation. This arrangement is shown in Fig. 2.

In some cases elevated track can be used to advantage and sand unloaded from hopper bottom cars without shoveling or use of crane. A typical arrangement of this character is shown in Fig. 3.

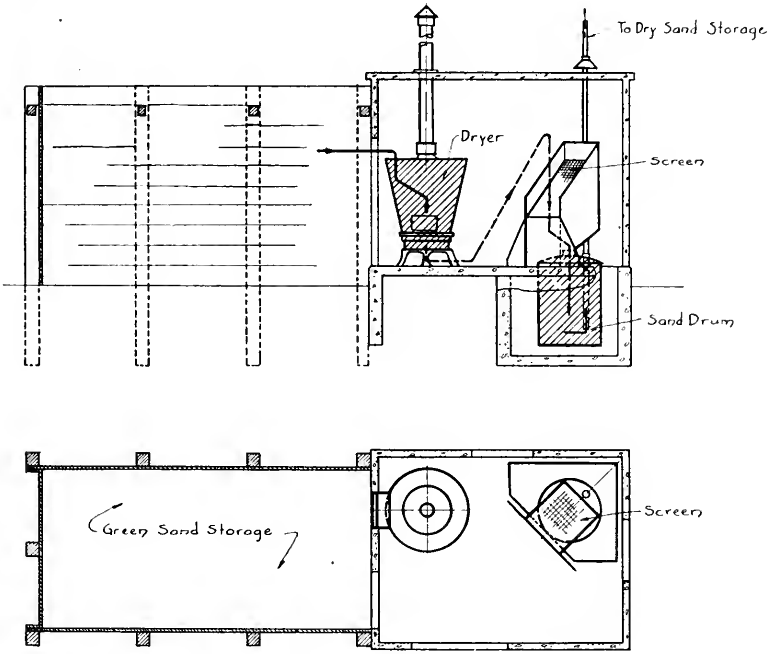


Fig. 1

An example of a relatively large installation of the ground storage type as recently constructed at an important terminal is shown in Fig. 4.

Type 2

In plants of this type advantage is taken of the fact that in constructing a coaling station the provision of an additional overhead bin for green sand storage can be made without greatly increasing the cost of the whole structure. Where skip hoists are used sand can be unloaded in the same hopper and elevated by the same equipment as that used for handling coal. This arrangement has the disadvantage of interrupting the unloading of coal while sand is being handled and requires the cleaning of the unloading hopper, both before and after the operation, but if the quantity of sand handled is not excessive and the periods are not too frequent (not to exceed once a week) these disadvantages are more than offset by the elimination

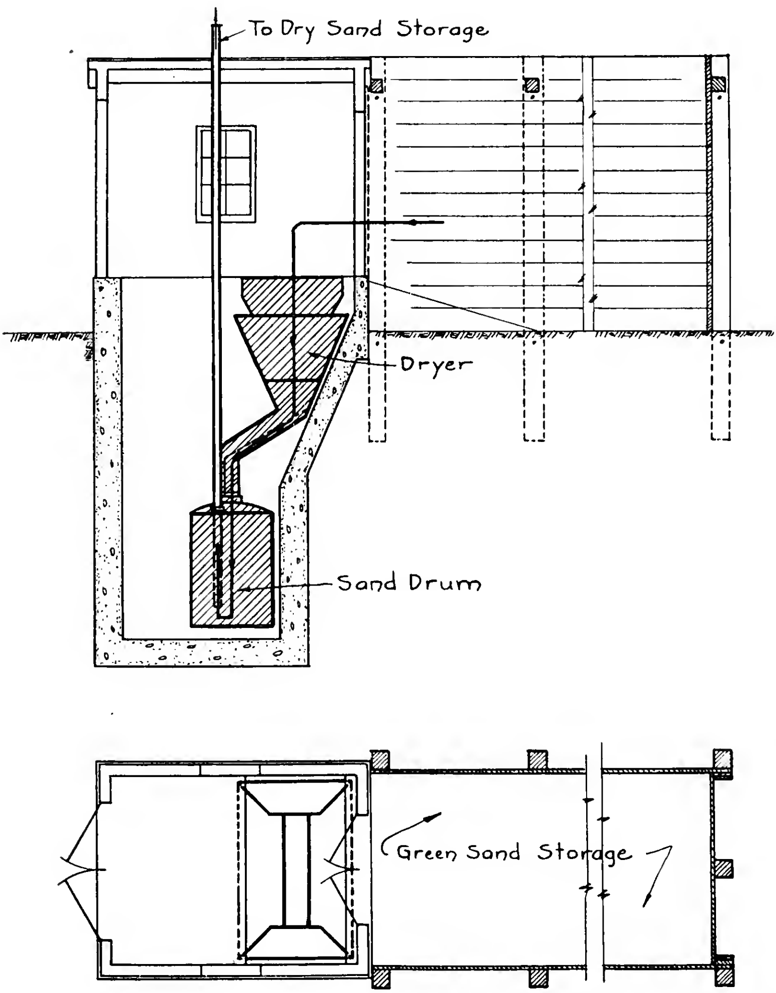


Fig. 2

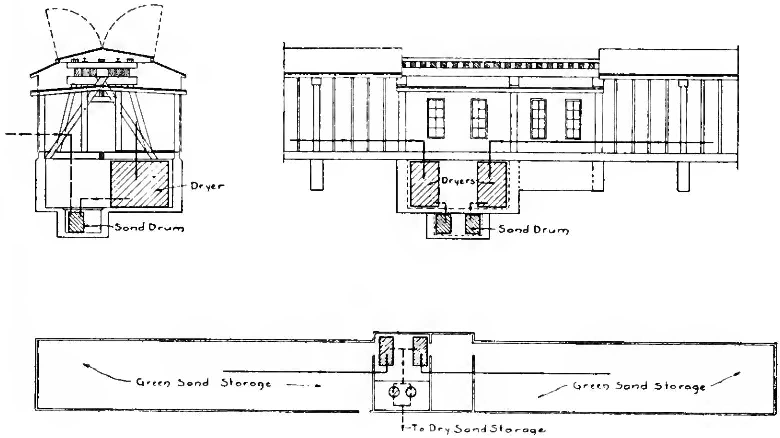

Dryer
Sand Drum
Dryers
Sand Drum
Green Sand Storage
Green Sand Storage
To Dry Sand Storage

FIG. 3

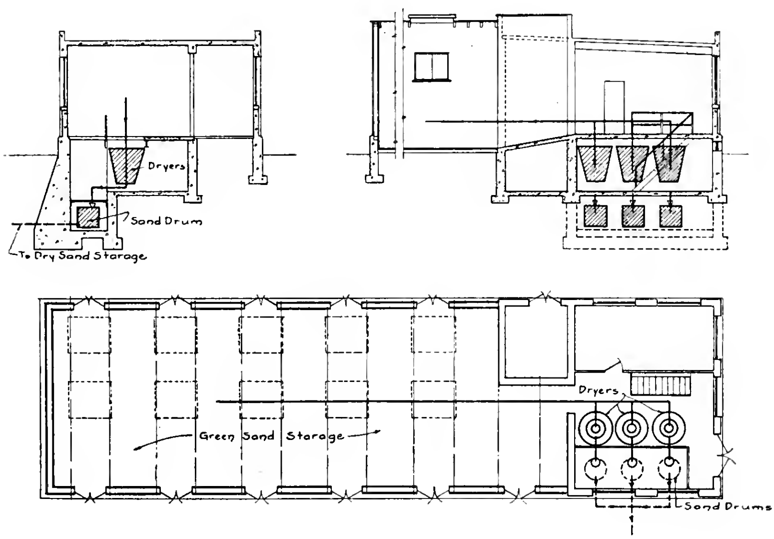
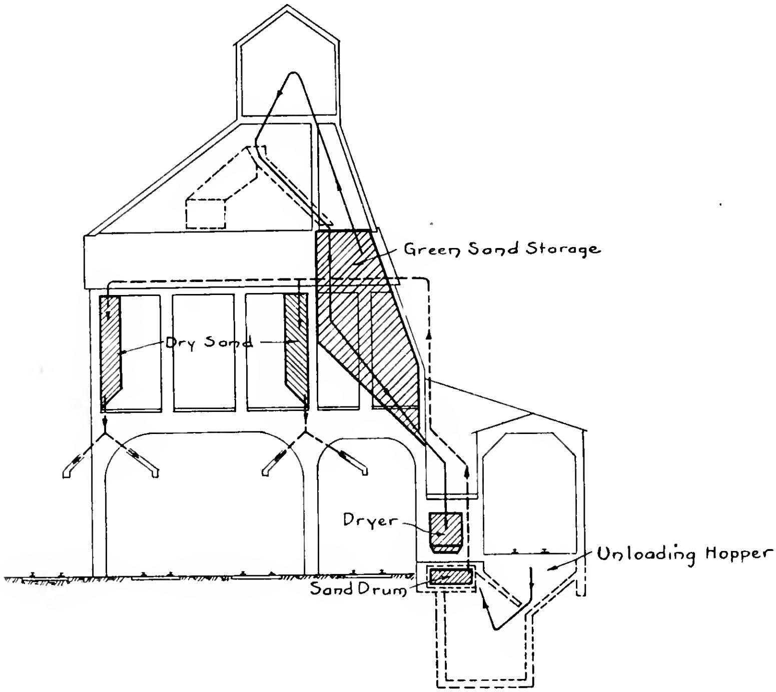
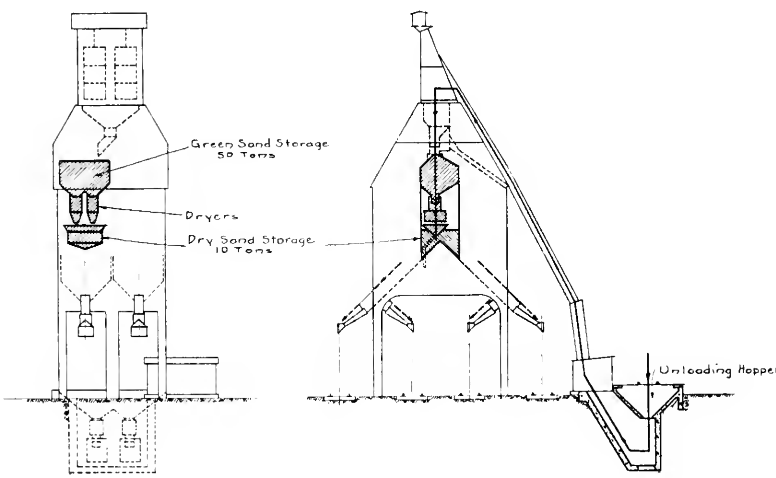

Dryers
Sand Drum
To Dry Sand Storage
Dryers
Green Sand Storage
Sand Drums

FIG. 4



Green Sand Storage
Dry Sand
Dryer
Unloading Hopper
Sand Drum

Fig. 5



Green Sand Storage
50 Tons
Dryers
Dry Sand Storage
10 Tons
Unloading Hopper

Fig. 6

of investment in separate facilities. The green sand bin can be arranged to deliver sand by gravity to driers and from driers to sand drum. Elevation to dry sand storage bin also in coaling station is accomplished by compressed air. A typical example of the arrangement above described is shown in Fig. 5.

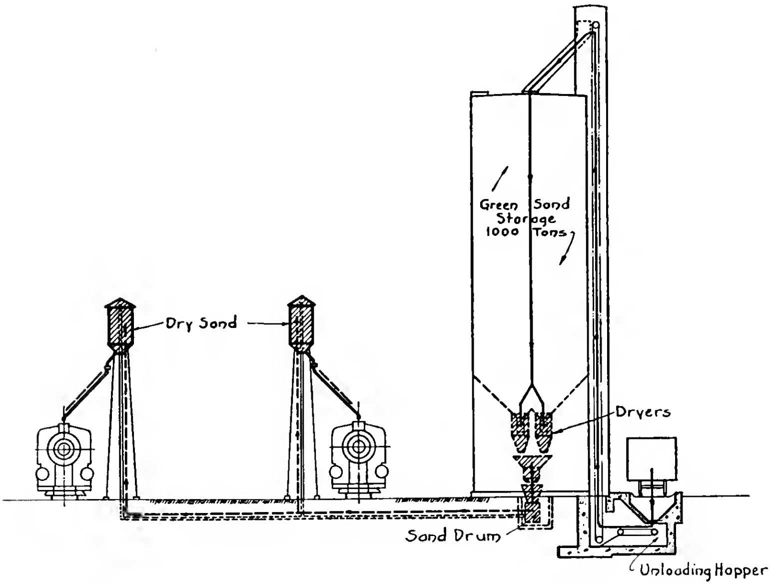


Fig. 7

Type 3

This type is very similar to Type 2 with the exception that a complete gravity handling is provided from green sand storage to delivery spouts to locomotives. This arrangement is possible where a small green sand storage bin is used and the coaling station is a relatively high and compact structure. A typical example is shown in Fig. 6.

Type 4

Where the handling of coal in a coaling station cannot be interrupted and where the quantity of sand to be handled justifies it, or in locations independent from coaling stations, a complete mechanical sand plant may be used. Such a plant usually consists of an independent hopper for the unloading of green sand from bottom dump cars, a mechanical conveyor of some sort for elevating the green sand, and one or more storage bins of the required capacity. From the storage bins gravity operation through the driers to the sand drum can be arranged. Dry sand is elevated by means of compressed air to the dry sand storage compartment, which may be located in an adjacent coaling station or entirely independent of same. Typical arrangements for complete mechanical sand plants are illustrated in Fig. 7, 8, 9, 10.

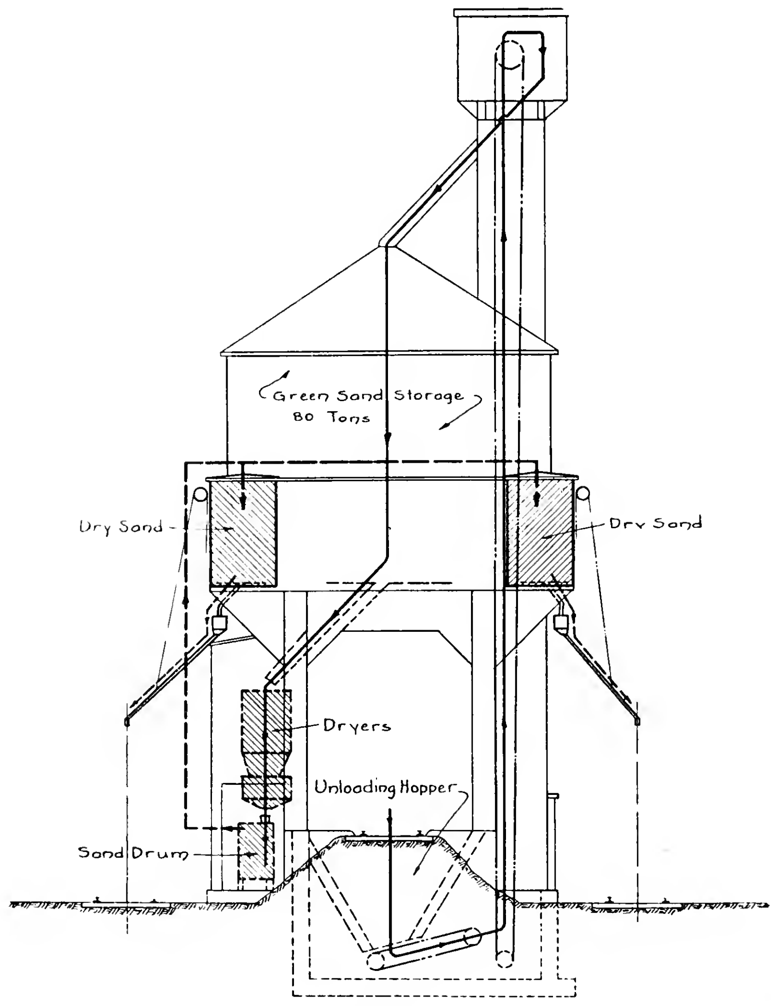

Green Sand Storage
80 Tons
Dry Sand
Dry Sand
Dryers
Unloading Hopper
Sand Drum

FIG. 8

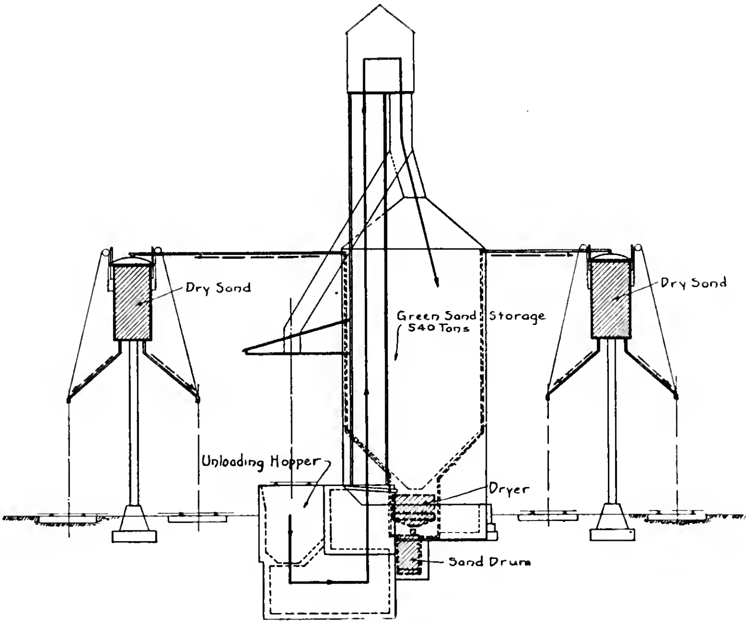

Dry Sand
Dry Sand
Green Sand Storage
540 Tons
Unloading Hopper
Dryer
Sand Drum

FIG. 9

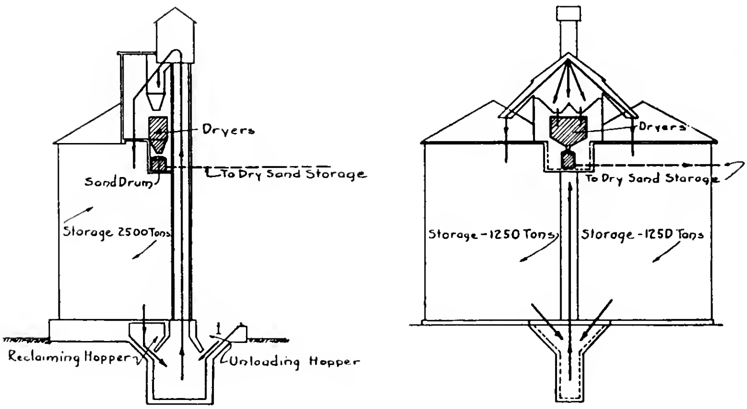

Dryers
Sand Drum
To Dry Sand Storage
Storage 2500 Tons
Reclaiming Hopper
Unloading Hopper
Dryers
To Dry Sand Storage
Storage - 1250 Tons
Storage - 1250 Tons

FIG. 10

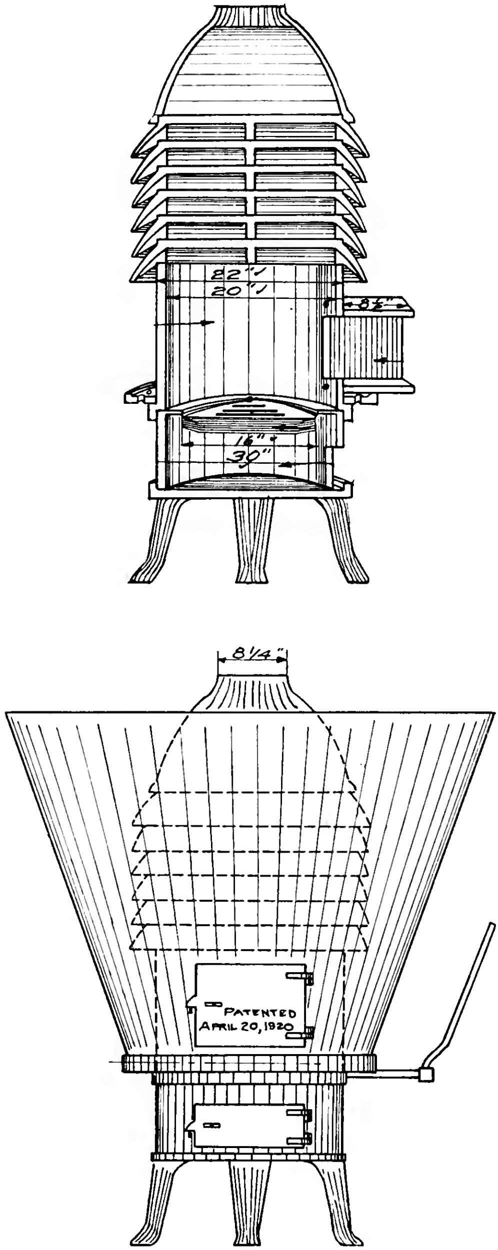


FIG. 11—SMALL STOVE SAND DRIERS

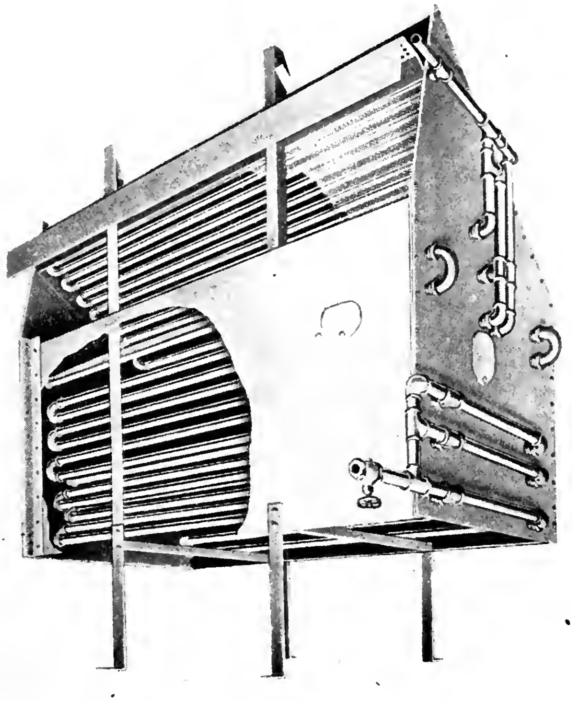


FIG. 12—STEAM SAND DRIER

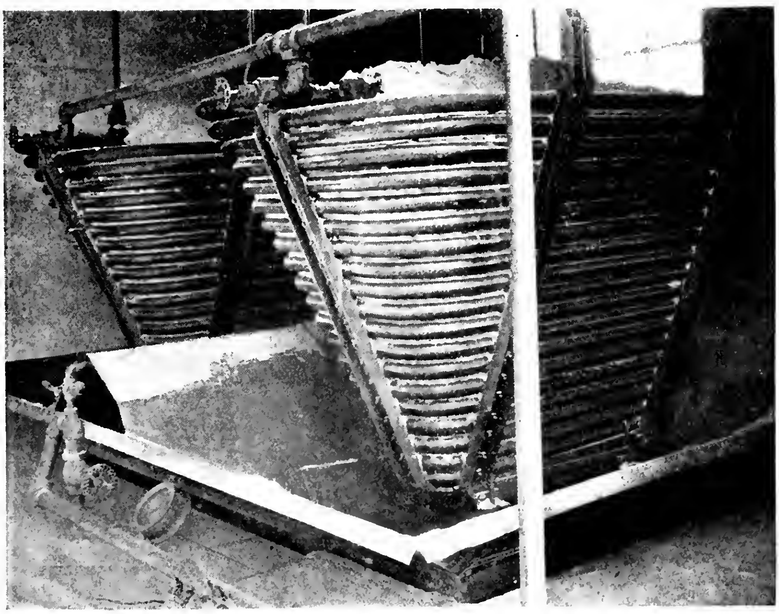


FIG. 13—STEAM SAND DRIER

A

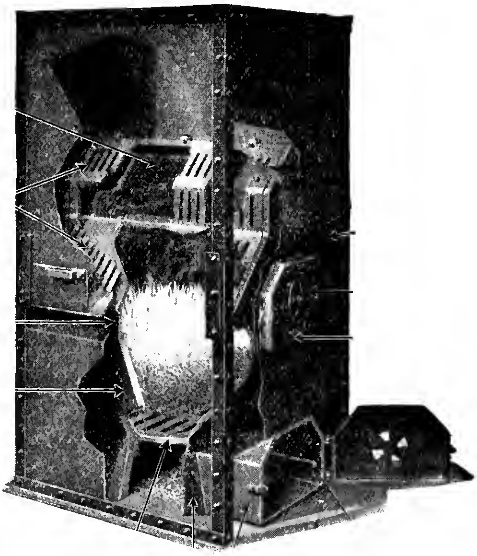


Fig. 14—Small Stove Sand Drier

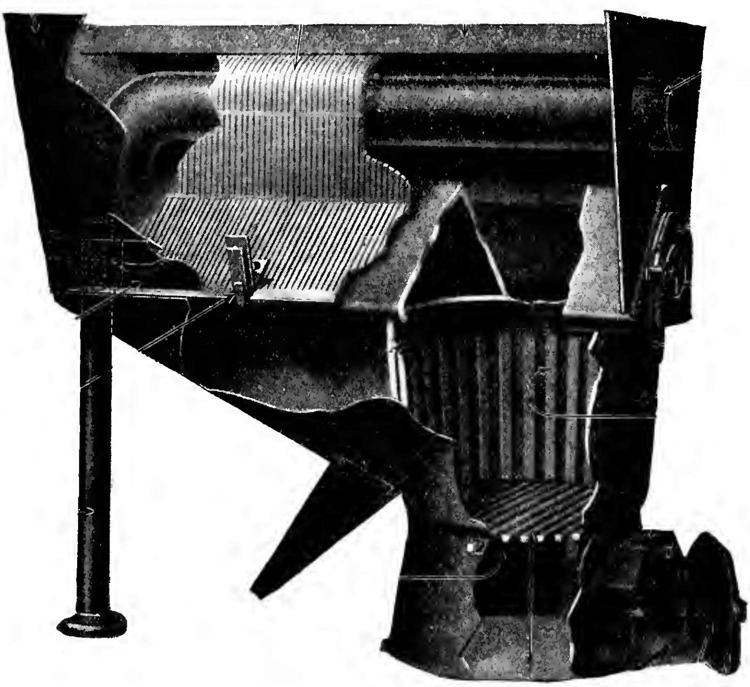


Fig. 15—Large Stove Sand Drier

GREEN SAND STORAGE

There seems to be no definite and uniform practice for determining the amount of green sand storage. In some localities deliveries cannot be secured during the winter and frequently even though deliveries can be secured sand freezes in cars before it can be unloaded. In such cases sufficient storage capacity to carry through the winter season should be provided. This usually means the provision of an independent sand handling plant. Where green sand storage space is provided for in the coaling station structure the minimum space provided should be one car load or at least one week's supply if more than a car load. In an average coaling station of 400 to 600 tons coal storage capacity, it is usually not unduly expensive to provide also for the storage of 100 to 150 tons of green sand.

HANDLING GREEN SAND

As previously stated, it is the usual practice in Type 1 or ground storage plants to use laborers with wheelbarrows for the delivery of green sand to the driers. The cars are unloaded either by hand shoveling or with a clam shell bucket on locomotive or some other type of crane. Where Type 2 or Type 3 plants are used the coal elevating equipment can be used also for sand, where such equipment is of the skip hoist type, by placing temporary choke over loader opening and partially filling the bucket. Continuous bucket conveyors designed for coal cannot be used for sand without serious overloading on account of the difference in weight of the two materials and in such installations separate conveyor for sand handling is required. It will be noted from Fig. 10, which illustrates one of the independent sand plants, that a rather ingenious arrangement has been provided which while it requires the re-elevation of green sand to driers after same has been placed in storage, it has the advantage of economy of construction by placing bottom of storage bin on the ground and permits delivery of dry sand to tracks by gravity.

DRIERS

Sand can be dried successfully in either stove or steam driers. Where steam supply is available from central shop power plant it is usually considered good practice to use steam driers, as they can be operated without so much manual attendance and the fire hazard is also reduced. In any case, building or compartment housing driers should preferably be entirely of fireproof construction. Sufficient drier units should be provided to keep an adequate supply of dry sand on hand at all times. Examples of successful stove and steam sand driers are illustrated in Fig. 11 and 12, respectively.

DRY SAND STORAGE

The capacity of dry sand storage bins varies considerably in actual practice, capacities ranging from 10 to 25 tons being generally used. The capacity selected for a given location should be sufficient to permit the establishment of a generous reserve for use during any unavoidable interruption in the operation of drier. When facilities are constructed in connection with a coaling station, dry sand storage compartment can readily be provided at some convenient location in that structure.

A

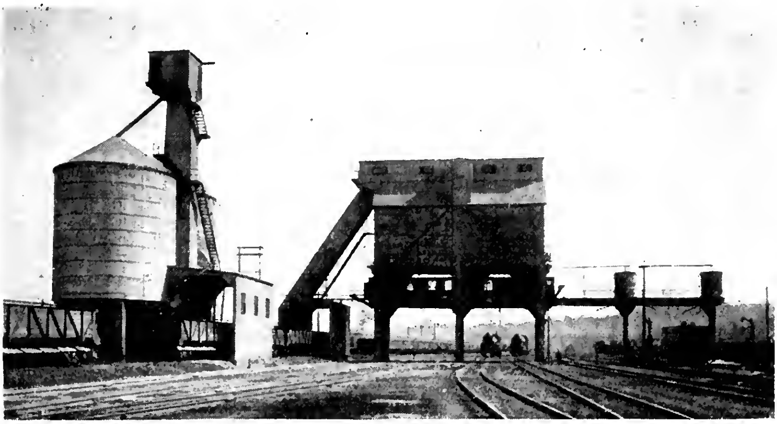
HANDLING DRY SAND

The generally accepted method of handling dry sand from drier to storage bin where gravity cannot be employed is by means of compressed air. In this method sand from drier is collected in batches of approximately one cubic yard in sand drum and air pressure is then applied. Usually 2½-inch pipe is used to convey sand from sand drum to storage bin. Such a pipe when properly installed can be used for the purpose without excessive wear. At points in pipe line where direction is changed it is good practice to use heavy tees with one tee opening plugged, thus forming a pocket which fills with sand for deflection purposes. Dry sand storage bin whether located in coaling station or independent of same should be placed at such an elevation that sand will readily flow by gravity to delivery fixtures. In cases where a large number of tracks are to be served it is sometimes necessary to provide two dry sand storage bins. Sand outlet fixtures for delivery to locomotives should be of the telescopic, counterbalanced type and equipped with weatherproof valves.

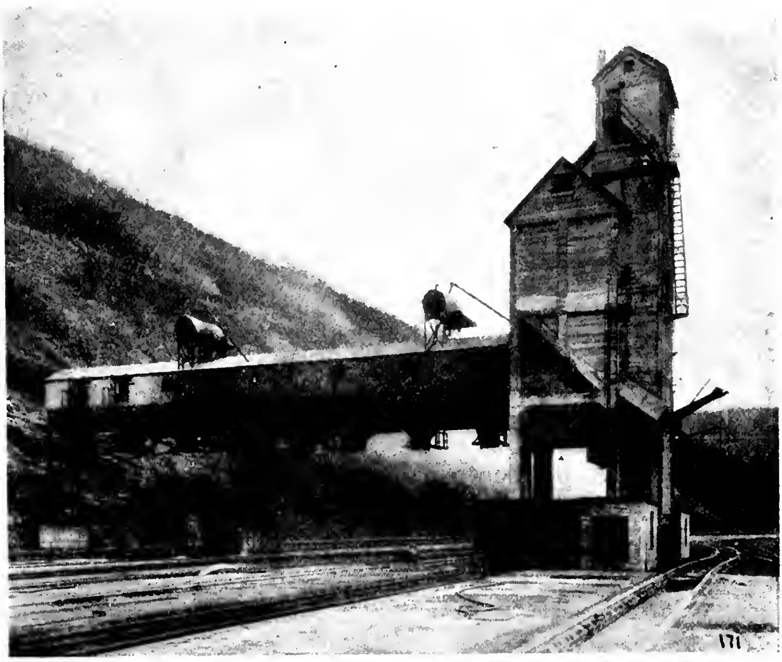
ILLUSTRATIONS

Photographs of a number of representative installations are also shown for further information.

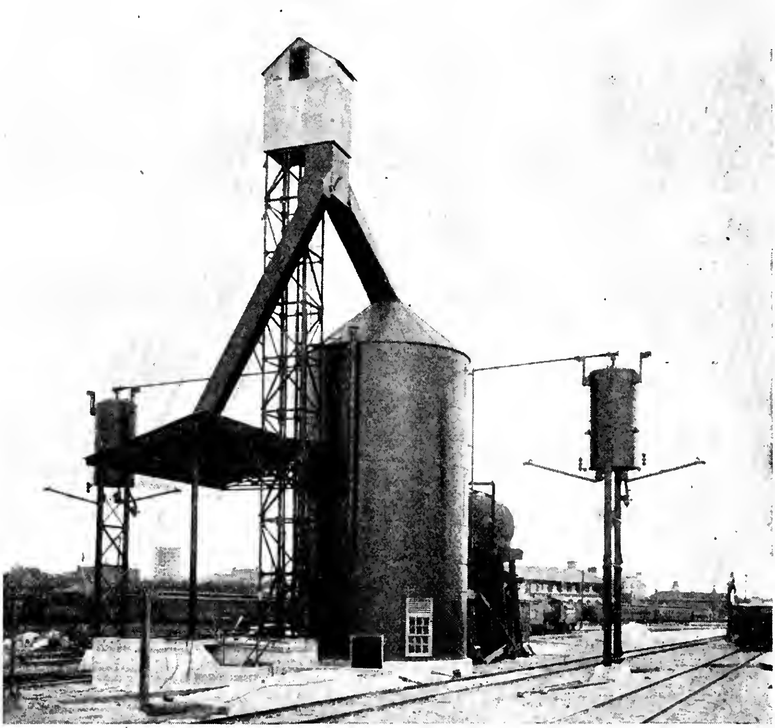
Coaling Station with Independent Sanding Facilities, Chesapeake & Ohio Railway



COALING STATION WITH INDEPENDENT SANDING FACILITIES



SEVENTY-FIVE TON OVERHEAD WET SAND BIN, PENNSYLVANIA RAILROAD



Independent Sand Plant, Atchison, Topeka & Santa Fe Railway

Appendix B

(2) LOCOMOTIVE REPAIR SHOPS

W. A. Radspinner, Chairman, Sub-Committee; N. Cory, C. T. Dike, C. E. Harris, W. T. Krausch, A. T. Hawk, L. K. Sillcox, H. W. Williams.

The ever-increasing size of modern locomotives and the application of various efficiency devices have caused a progressive growth in size of shops and equipment to maintain the locomotives repaired therein.

The accompanying illustrations contain sectional diagrams of typical shops built during the period of 1900 to 1928 and illustrate some of the lines of growth and development of the shop for locomotive repairs.

In the longitudinal shops, attention is called to the increased spacing of repair tracks, wider and higher erecting and machine bays and increased capacity of cranes; in the transverse shops the width and height of erecting bay and the capacity of cranes. In both types of shops a feature of considerable importance is the increase of shop area provided for machine shop purposes.

Some of the older shops have been improved to handle the heavier motive power by adding new erecting bays, installing special type cranes for lifting locomotives in limited headrooms and special jacks for unwheeling. These improvements, while of great help, cannot take the place of properly designed modern shops.

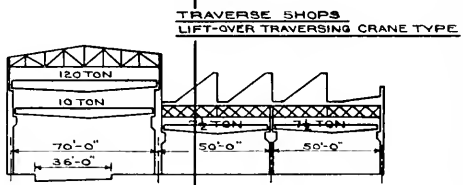
Lack of proper facilities usually results in a shortage of power or necessitates the purchase of additional locomotives in order to supply adequate service, and also results in an increase in the cost to maintain power.

The new shop constructed today will be continued in service for at least 25 or 30 years and should be so arranged that it may be conveniently enlarged and at the time built should be large enough not only to take care of the largest locomotive on the line of road today, but sufficiently large to take care of any reasonable increase in size of power.

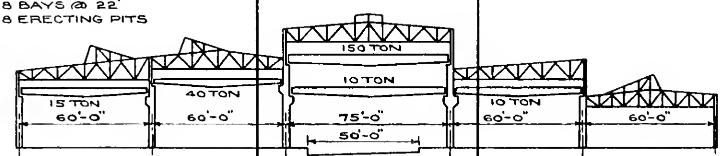
The increase in size of parts of locomotives during the past 25 years naturally alters the procedure in laying out a modern shop; on account of the parts being so much heavier it is now necessary to provide mechanical means and lifting devices for many parts that were formerly handled by man power.

Twenty-five or thirty years ago skilled mechanics received 20 cents to 25 cents per hour and worked ten hours per day. Today the same class of mechanics receive 75 cents to 80 cents per hour and work only eight hours per day. Common labor at that time received $1.00 per day—12 hours per day or 8 cents per hour—while today this class of labor receives 35 cents to 45 cents per hour and works 8 hours per day. By agreement with the labor organization there has been introduced in more recent years the helper, who receives 50 cents to 60 cents per hour, and performs work formerly done by common labor.

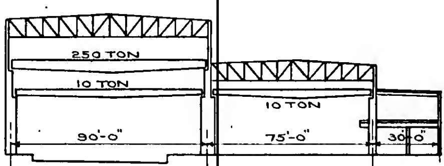
BUILT 1902
BUILDING 170'x528'
24 BAYS @ 22'
24 ERECTING PITS



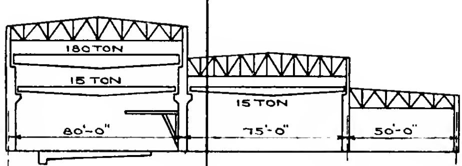
BUILT 1914
BUILDING 315'x616'
28 BAYS @ 22'
28 ERECTING PITS



BUILT 1919
BUILDING 195'x390'
16 BAYS @ 24'
15 ERECTING PITS
ALSO SERVED BY
TRANSFER TABLE

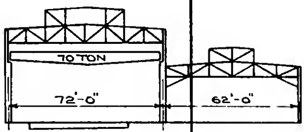


BUILT 1925
BUILDING 205'x525'
21 BAYS @ 25'
15 ERECTING PITS

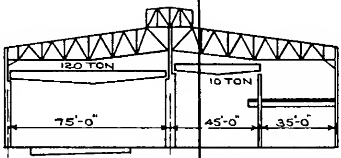


TRANSVERSE SHOPS
SERVED BY TRANSFER TABLE.

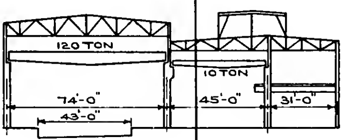
BUILT 1902
BUILDING 134'×540'
24 BAYS @ 22'-0"
15 ERECTING PITS



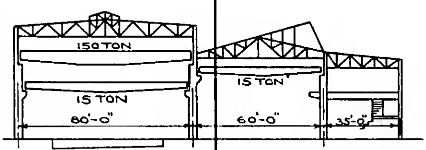
BUILT 1902
BUILDING 150'×486'
24 BAYS @ 20'-0"
10 ERECTING PITS

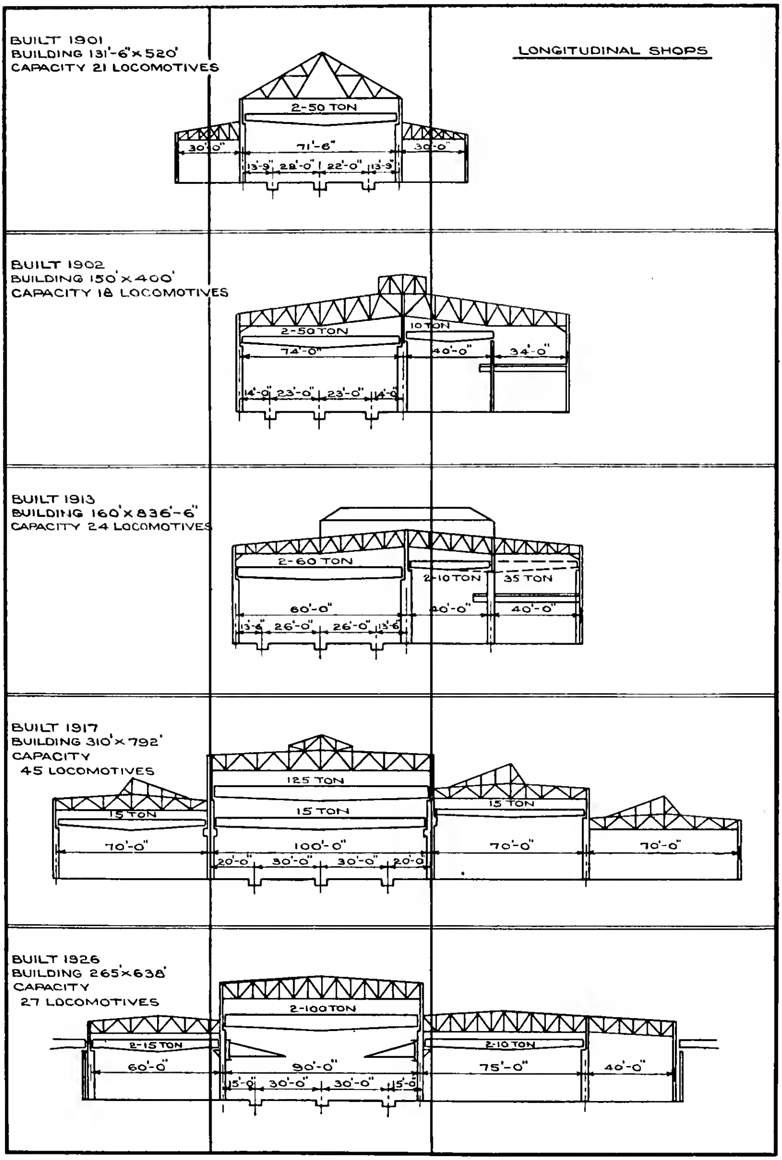


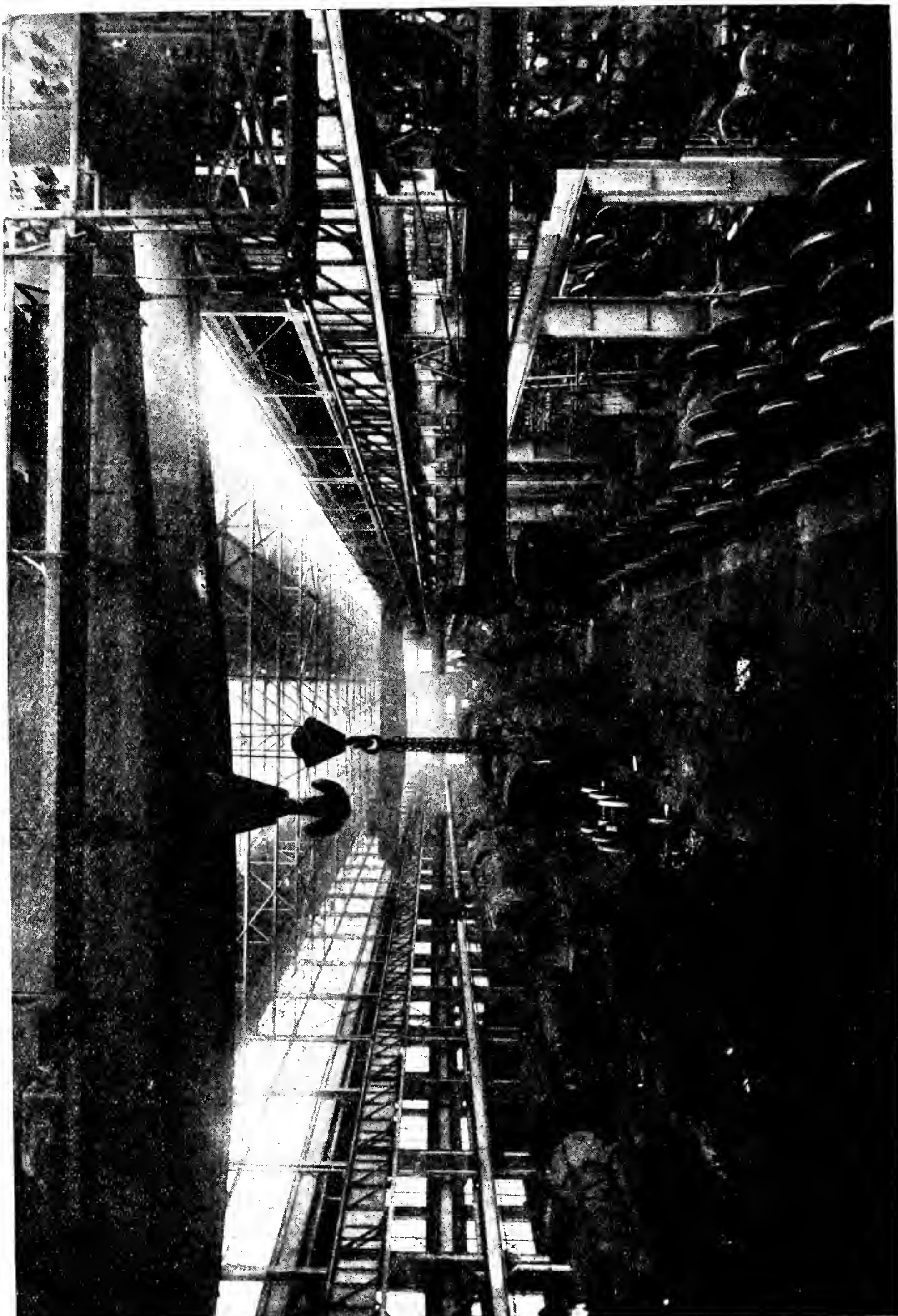
BUILT 1910
BUILDING 152'×220'
10 BAYS @ 22'-0"
6 ERECTING PITS



BUILT 1924
BUILDING 175'×568'
25 BAYS @ 22'-6"
25 ERECTING PITS




LONGITUDINAL SHOPS
BUILT 1901
BUILDING 131'-6"x520'
CAPACITY 21 LOCOMOTIVES
2-50 TON
30'-0"
71'-6"
30'-0"
13'-9" 28'-0" 22'-0" 13'-9"
BUILT 1902
BUILDING 150'x400'
CAPACITY 18 LOCOMOTIVES
2-50 TON
10 TON
74'-0"
40'-0"
34'-0"
14'-0" 23'-0" 23'-0" 14'-0"
BUILT 1913
BUILDING 160'x836'-6"
CAPACITY 24 LOCOMOTIVES
2-60 TON
2-10 TON
35 TON
60'-0"
40'-0"
40'-0"
13'-6" 26'-0" 26'-0" 13'-6"
BUILT 1917
BUILDING 310'x792'
CAPACITY
45 LOCOMOTIVES
125 TON
15 TON
15 TON
15 TON
70'-0"
100'-0"
70'-0"
70'-0"
20'-0" 30'-0" 30'-0" 20'-0"
BUILT 1926
BUILDING 265'x638'
CAPACITY
27 LOCOMOTIVES
2-100 TON
2-15 TON
2-10 TON
60'-0"
90'-0"
75'-0"
40'-0"
15'-0" 30'-0" 30'-0" 15'-0"



It is apparent from the above that all practicable means of eliminating manual labor should be utilized. Probably the greatest step in this direction is the overhead traveling crane; individual jib cranes, portable and fixed; trucks, tractors and trailers for material handling.

The ratio of locomotives to be shopped, per mnoth or per annum, to the number of locomotives operated by a railroad depends upon:

(a) Operating conditions on the railroad.
(b) Policy of the management as to time of shopping locomotives.

One of the best methods used in measuring and controlling the shopping of locomotives is the mileage basis, in which the actual mileage of individual locomotives is recorded, and an average mileage for the different classes of locomotives between shoppings is determined from experience with the particular class of power and operating conditions.

If such a method is used the demand upon the shop can be fairly accurately predicted.

Size of Shop

Assuming a properly balanced shop—the output of a shop is determined by two factors.

(a) Number of spots provided in the shop.
(b) Average length of time required in shop by each locomotive.

The average length of time required in the shop by each locomotive varies with individual roads and with conditions.

The kind of locomotives, number of repairs of the different classes, the method of operation of the shop and the policy of the individual railroad have an important bearing on the average time required in the shop per locomotive. This average time must be determined from the conditions on the individual railroad. Generally speaking, the average of most railroads seems to be one to one and one-half locomotives per month per spot, depending upon the type of power, the proportion of the different classes of repairs, and the extent to which adequate repairs and handling equipment has been provided.

In order to get the opinion of those now operating large shops of old or modern design, a questionnaire was prepared and sent out to representative companies in the United States and Canada, to which replies were received from twenty-five railroads, one locomotive manufacturer and one architect. This questionnaire asked, in most instances, for a preference of stated design, and brought out replies which, in some cases, were not a direct answer to the question. This variation prevents giving the replies in table form because it is thought best to include some of the comments. The information in regards to combined transverse and longitudinal shop was not developed until after questionnaire was submitted and replies received.

Type of Shop

There are two distinct types of locomotive repair shop:

The Transverse The Longitudinal

The question of whether to adopt a longitudinal or transverse type of erecting shop has been the source of more discussion than any other subject connected with the layout of locomotive repair shops. Each type of shop has its merits and the adoption of one type over the other will depend primarily on three considerations, namely:

Personal preference,
Property restrictions,
Possibility of radical change in length of power to be maintained.

Several recently constructed large shops have been of the transverse type, a fundamental advantage of this type is the right angle movement resulting from the cranes operating crossways of the track, which permits a better distribution of material and work between the engines and the machine tools, also allows a better grouping of supervisory forces and workmen. The longitudinal shop is better adapted to the "station to station" system of repairs, and can be better adapted to radical change in length of locomotives.

Longitudinal Shops

In the longitudinal type of shop there are three types of cross section of the erecting or repair bay.

(a) Equipped with one level crane runway,
(b) Equipped with one level crane runway and traveling jib cranes along column rows beneath,
(c) Equipped with cranes on two levels.

In operation, the engines generally enter one end from a ladder track. They may leave at the same end or progress through the shop and leave at the opposite end.

In modern shops the erecting bay varies from 90 to 100 feet wide with three repair tracks spaced 30 feet centers. In most shops the track pits extend practically the full length of the shop.

The crane equipment in the erecting bay consists of two cranes of sufficient capacity and high enough to move engines down the shop when suspended between others on the tracks. In addition to the heavy cranes, lighter cranes on lower runways are provided for stripping and messenger service. These may consist of 15-ton cranes spanning the erecting bay or of traveling jib cranes on each line of columns.

Transverse Shop

In the transverse type of shop there are three types of cross-section:

(a) With a total absence of crane service,
(b) Equipped with one level runway,
(c) Equipped with cranes on two levels.

Type (a) is served by ladder tracks or a transfer table.

Type (b) and (c) may be served by a transfer table, one or more entrance tracks or turntables as ground conditions or track arrangements will permit.

Where a transfer table is provided, the high level, two trolley cranes may be of capacity and height to lift unwheeled engines over others standing on the floor. In shops where one or more entrance tracks are provided, the high level crane must be of capacity to transport a wheeled engine clear of others on the floor.

The stripping cranes are usually 15-ton capacity.

In some shops, jib cranes are placed on alternate building columns at the front end of the locomotive for use in front end stripping and repair work.

Combined Transverse and Longitudinal Shop

Recently the progressive system of shop operation has not only been given serious consideration but in some instances adopted. Inasmuch as certain repairs cannot be made without disturbing the progressive order of repairs and are best made on separate spots, it would seem that a combined transverse and longitudinal shop would be best adapted to this method of operation. This will permit the repairs, common to all locomotives, to be done in the longitudinal bay under the progressive method while the additional work incidental to the different classes of repairs can be done on a fixed position in the transverse portion without interference with movement of locomotives in the progressive system. It would permit the least handling of parts between the locomotive and the various shop departments.

Questionnaire

1. Q. Were you to lay out a shop for the general overhauling of locomotives for your road, would your preference be for the longitudinal or transverse type? Please give your reasons.

   Replies to the questionnaire indicated a preference of six longitudinal; 20 transverse.

2. Q. What spacing of tracks, center to center, should be provided: (a) Transverse type; (b) Longitudinal type.

   A. Ranges from 22 to 30 feet for longitudinal—majority 30 feet. Ranges from 22 to 28 feet for transverse—majority 25 feet.

3. Q. What proportion of total floor space should be provided for erection bay and machinery bay in (a) Transverse type; (b) Longitudinal type?

   It is recommended by several roads that the amount of space required should be determined only after a careful study is made of the requirements. A suggested solution of the problem is to consider the type of locomotives which are to be repaired, making ample provision for repairs to the locomotive proper, and in addition, to all of the modern accessories used, such as feed water heaters, boosters, stokers, superheaters, train control, grate shakers, power reverse gear, automatic fire doors, etc. A careful time study should be made of all the machine tool operations, then allow sufficient space in the building to take care of the required machinery. On this principle the entire size of the shop depends. For example, it is desired to give general repairs to fifty locomotives per month, having an average of five pairs of driving wheels per locomotive, there will be 250 sets of wheels to have tires turned, 500 driving boxes to have each of several operations performed thereon, and it is necessary to provide sufficient machinery to do the work without delaying other operations.

The rate at which locomotives must be turned out of shop to produce a given monthly output is found by dividing the total working hours per month by the desired output. This rate of output applies to every major operation, therefore, sufficient machinery must be available to turn five pairs of driving wheels, bore ten driving boxes, etc., in the allowable time otherwise the shop will not be balanced.

The replies indicated the following division of space:

(a) and (b) Ranges from 30 per cent to 50 per cent total floor space for erecting.

(a) and (b) Ranges from 70 per cent to 50 per cent total floor space for machinery.

4. **Q.** Do you prefer to have boiler shop segregated from machine shop and erecting shop or in the same building? Please give reasons.

(a) Transverse type; (b) Longitudinal type.

A. (a) Transverse—preference is 15 for separate shop; 11 for same shop.

(b) Longitudinal—many did not give a preference. Of those that did, the preference is eight for a separate shop; six for same shop.

The reasons given for a separate shop are that it eliminates noise. Each group gave as a reason for the combined shop the matter of convenience for crane operation and supervision.

5. **Q.** Should the stripping operation be handled at one place or on every pit in the transverse type of shop? If at one place, do you favor a separate building for this?

A. 20—Main shop,
6—Each or several pits,
13—One place,
5—Separate building.

6. Q. What is your preference for the wheeling and unwheeling operation?

(a) Whiting hoist? (b) Overhead crane? (c) Drop table?

Please give reasons.

A. (a) 1—Whiting hoist,
(b) 26—Overhead crane,
(c) 0—Drop table.

The reasons given for preference of overhead crane were almost unanimously convenience, flexibility and speed; for the Whiting hoist, economy in first costs.

7. Q. What depth of pit do you recommend in the erecting bay?

A. Replies ranged from two feet to three feet depth for a straight bottom pit, to sloping pits of a maximum depth of four feet, and one road does not favor pits in the erecting shop. The majority favored a sloping pit with a crowned surface two feet six inches deep at the high end and three feet at the low end. The reason for the sloping pit was to provide good drainage.

8. Q. What kind of floor do you recommend, concrete or wood block on concrete base, or asphalt mastic on concrete base?

(a) Erecting bay; (b) Machinery bay; (c) Boiler shop.

A. Some railroads specified other than the material stated in the questionnaire, and others call attention to certain operations requiring special consideration, such as in front of furnaces handling hot materials (for example, annealing furnaces in a boiler shop), where vitrified brick is recommended, and for flooring under tender tank repair racks and boiler plate drilling machinery where concrete, sloping to a drainage pit, should be used.

17—Wood block on concrete for all purposes,
2—Asphalt mastic on concrete for all purposes,
2—Concrete for all purposes.

Total replies indicated the following:

	Wood on Concrete	*Asphalt Mastic on Concrete*	*Concrete*	*Cinders, Cuttings, Gravel, Etc.*
Erecting Bay	21	4	2	0
Machinery Bay ...	20	5	2	0
Boiler Shop	16	0	4	2

9. Q. Would you recommend an overhead crane with sufficient clearance to permit moving locomotive over those on pits in preference to transfer table? If so, under what conditions?

A. 24—Crane.
3—Transfer table.

Five of those preferring the crane would like to have both the crane and the transfer table.

The reason given for crane preference is that of efficiency, flexibility, and that it keeps all the work inside the shop, eliminates unnecessary doors and thus makes it easier to heat and maintain the building.

10. Q. Where transfer table is used, what space should be provided between the shop wall and edge of table pit?

A. The replies ranged from ten feet to that of ten feet longer than the longest locomotive.

11. Q. Do you favor piping shop throughout for air, water, acetylene and oxygen, and wiring for electric welding?

A. All the replies favored the stated conveniences and, in addition, steam and both high and low pressure water lines for service and testing boilers.

12. Q. What is your preference as to location of lavatory, wash room and locker room; on ground floor or mezzanine?

A. A great many replies to this question indicated that the stated location did not cover the ground and added their preference as follows:

	Ground Floor	*Mezzanine*	*Separate Building*
Lavatory	16	7	3
Wash Room	12	9	5
Locker Room	13	8	5
Urinals	4	..	..

After reviewing the different replies to the questionnaire sent out, it is our opinion that this Committee is not justified in laying down any fixed rules as to the type or size of shop to be recommended by the A.R.E.A.

It is thought that certain principles involved are common to every railroad and that, before a shop is planned, there should be a definite knowledge of what the shop is expected to do, so an additional questionnaire or Report of Inspection of Locomotive Repair Shops has been prepared which, we think, would contain the data which should be known by any railroad desiring to erect a locomotive repair shop. Then their own problems can be compared with the collective data of railroads operating shops similar to those they desire to build.

The Shop Engineer and Designing Engineer, with this data, should then develop a plant to suit the problems of the individual railroad.

If, however, a hurried estimate is desired, the principles and dimensions outlined in answer to our original questionnaire would serve as a very satisfactory guide.

The matter of constructing a building will vary with the conditions set out in the beginning of this report. The following conditions should be considered as good practice:

Building Construction

The cross section of the building is determined by the crane heights and loadings. The wheel loads of the heavy cranes are much greater than those of the heaviest locomotives and careful assumptions must be made of loadings and side and end thrusts to provide a structure which is both safe and economical.

Careful attention should be given to the foundation designs and to the anchoring of structures to resist wind loads and side thrusts of cranes.

The provision of ample natural light is of considerable importance.

The varying heights of the different bays give an excellent opportunity to use continuous steel sash between roofs of different levels. These can be supplemented by skylights over the erecting bay and longitudinal sawtooth lighting over the lower bays. An alternate to these roof lights can be made by building alternate roof panels on the top and bottom chords of the trusses with continuous top hung steel sash alongside of the trusses.

Side and end walls of brick, anchored to the steel work, with steel sash grouped in large units provides the most satisfactory enclosure of the building. All movable sash and ventilating panels should be glazed with wire glass; fixed sections of side wall sash may be glazed with clear or plain ribbed glass. Glare and direct sun rays should be guarded against and glass is now made which kills the glare and improves the diffusion of light inside the building.

Floors of wood block on a concrete base have proved satisfactory for the heavy shop service. In some departments, floors of asphalt block or cement finish can be used.

Swinging wood doors for tracks and other large openings are the most economical and quickest in operation. Where these have been unsatisfactory, it has been generally due to poor design.

As a further guide in selecting a modern locomotive repair shop, plans and photographs of the most recently completed shops of both the transverse and longitudinal type are submitted without comment as information.

REPORT OF INSPECTION OF LOCOMOTIVE REPAIR SHOPS OF THE .... RAILROAD LOCATED AT ....

General

1. Date built ....
2. Built by ....
3. Designed by ....
4. No. of Pits ....
5. Normal output capacity in classified repairs per month..............
   U.S.R.R.A. Class 2—(a) General Repairs—Including new fireboxes..
   " " 3—(b) General Repairs—Without new fireboxes..
   " " 4—(c) Medium Repairs ....
   " " 5—(d) Light Repairs ....
   Total output class repairs per month..............................
6. Transfer—Yes .... No ....
7. Heating Equipment ....
8. Total number of employees Locomotive Shop........................
9. Principal class of power handled:
   (a) Freight ....
   (b) Passenger ....
   (c) Switch ....
   Total number of locomotives depending upon this shop for class repairs ....
10. Location wash and locker rooms..............................
    (a) In separate buildings ....
    (b) In main buildings ....
    (c) In main building galleries ....
11. Is shop equipped with auto-telephone system........................
12. Is shop equipped with pneumatic tube system for transmitting material orders and written instructions ....

DEPARTMENTAL DETAILS

Erecting Shop

13. Type of Erecting Shop—Longitudinal ....
    Transverse ....
14. Number of pits ....
15. Distance between track centers ....
16. Where are parts stored after completion and before called for by erecting shop ....
17. Where are cabs stored ....
18. Number and capacity of overhead cranes for lifting locomotives......
19. Number and capacity of messenger cranes........................
20. Span of cranes ....
21. Height floor to large crane track..............................
22. Height floor to messenger crane track .... ft.
23. Width of erecting shop ....
24. Length of erecting shop ....
25. Is shop piped for oxygen gas ....
26. Is shop piped for acetylene gas ....
27. What kind of acetylene apparatus ....
28. Size of main air line in erecting shop ....
29. Size of drops ....
30. Size and number of outlets per pit..............................
    Location of air line outlets in pits on columns..................
31. Location of portable electric light outlets ....
32. Location of work benches in erecting shop ....
33. Size of work benches in erecting shop ....
34. Kind of floor ....
35. Width .... Length .... Depth .... of pits

36. Are pits heated—Yes .... No ....
37. Where are driving wheels stored when not being worked.............
38. Are engine trucks and trailer trucks overhauled in erecting shop Yes .... No ....
39. Where are lye vats located ....
40. Are there blacksmith forges and small air or steam hammer located in erecting shop for small work applied to engines ....
41. (a) Are portable bolt lathes used ....
(b) If so, how many pits does one serve ....
42. Is shop wired for electric welding or are portable welders used.......
43. What system of lighting ....

Machine Shop

(a) What is length and width of heavy machine shop .... by ....
(b) What is length and width of light machine shop .... by ....
(c) What is area of machine shop ....
(d) How many sq. ft. per erecting pit......................... sq. ft.
Is the driving wheel work performed in main heavy machine shop bay....
If so, what portion of this bay does the wheel work occupy................
(a) How many cranes ....
(b) What capacity ....
(c) What span ....
(d) Height floor to rail ....
Where is the bolt gang located with respect to center of erecting shop....
Are bolts turned to standard tapers kept in stock in machine shop ready to cut off to length and thread.......................................
Are machines grouped to specialize on work by classes such as:

(a) Motion work
(b) Shoes and wedges
(c) Driving wheels and axles
(d) Driving boxes
(e) Spring rigging
(f) Brake rigging

Are machines located with respect to natural sequence of operations to avoid back handling ....
Is A.C. power used with gear boxes or are variable speed motors used with direct current ....
(a) If driving wheel work is done in separate bay, where is it located with respect to center of erecting shop....................................
(b) What is length and width .... feet by .... feet
Is driving box work adjacent to driving wheel work.....................
Where are stokers overhauled ....
Where are engine and trailer trucks overhauled..........................
Where are the following parts overhauled:

(a) Air brake schedules
(b) Safety valves.
(c) Injectors
(d) Lubricators
(e) Feed water heaters
(f) Boosters
(g) Power reverse gears
(h) Power grate shakers
(i) By-pass valves
(j) Drifting valves
(k) Cab cocks and valves
(l) Boiler checks
(m) Tank valves
(n) Throttle levers.
(o) Foundation brake rigging.
(p) Spring rigging.
(q) Superheater units

Boiler Shop

Location with respect to erecting shop...................................
Is the boiler shop divided into:
- (a) Erecting bay
- (d) Fabricating bay
- (c) Light bay for ashpan and cab work
- (d) Size of boiler shop .... by ....

Size of Rolls
Hydraulic Flanging Press
- (a) Size
- (b) Type
- (c) Capacity

- (a) Size of flange clamps
- (b) How operated

Size of annealing furnace
List of machine tools
- Punches
- Shears
- Rotary shears
- Slitting shears
- McCabe pneumatic flanger
- Cranes
- (a) Number of cranes ....
- (b) Capacity of cranes ....
- (c) Span of cranes ....

Floor construction ....

Staybolt Manufacturing

- (a) Kind of threading machines
- (b) Kind of drilling machines
- (c) Kind of taper threading machine for crown bolts
- (d) Method of squaring bolts

Flue Work

Kind of rattler
Kind of welding machines
- (a) Hammer
- (b) Rotary
- (c) Electric

Distance from erecting shop
Method of handling to and from erecting shop

Tank Shop

Are locomotive tender frames and cisterns overhauled in boiler shop or in separate tank shop...................................
How many tenders can be spotted for repairs at one time.................
Are tender trucks repaired at same location as tanks and frames..........
Crane Facilities:
- (a) Number of cranes
- (b) Capacity
- (c) Height above floor
- (d) Span of cranes
- Is sufficient machinery located in tank shop to avoid handling parts to other departments ....

Blacksmith Shop

Length and width .... by ....
Height to roof truss ....
Overhead cranes ....
Number and capacity of steam hammers ....
Number and capacity of hydraulic forging hammers ....
Number and capacity of drop hammers ....
Number and capacity of bull dozers....................................
Number and capacity of forging machines ....
Air Blast Blower Line:
(a) Location—Overhead .... Underground ....
(b) Size and number of blowers used
(c) Pressure on blast line
Type exhaust system
Are down draft forges used—Yes .... No ....
Number and size of heating furnaces for serving steam hammers..........
Capacity of jib cranes serving large hammers..........................
Does this smith shop perform work for other than locomotive repairs in this particular shop .... If so, for what points ....
Are main and side rods annealed periodically ....
To what extent is heat treating of rods, axles and crank pins carried on....

Pipe Shop

Where is the pipe shop located with respect to erecting shop ....
Size of pipe shop ....
Where are pipes stored when removed from locomotives..................

Jacket Work

Where located with respect to erecting shop............................
Size of jacket shop ....
Where are jackets stored when removed from locomotives ....

Asbestos Shop

Where is asbestos shop located with respect to erecting shop ....
How is broken asbestos reclaimed ....
Is there a band saw in asbestos shop ....
Is there a molding press and baking oven used..........................

Tool Room

Is the manufacturing tool room separate from the distributing tool room....
Is there a separate tool room:
(a) In boiler shop
(b) In erecting shop
Are high speed steel tools ground to standard shapes and supplied from tool room ....
Are mechanics permitted to grind tools to suit themselves in shops........
Where are tool rooms located:
(a) Manufacturing
(b) Distributing
(c) Boiler shop
(d) Erecting shop
Is tool room equipped with tool hardening furnaces ....

Electrical Shop

Where located ....
Size of electrical shop ....
Electric baking ovens ....

Engine Carpenter Shop

Location ....
Size ....

Foundries

(a) Iron—Size .... by .... Output Capacity .... tons per month
(b) Brass
(c) Steel

Power Plant

Do you generate electric power ....
Do you purchase electric power ....
What type of boilers ....
Are boilers superheated ....
Boiler pressure ....
How many boilers ....
How many H.P. each ....
Total boiler H.P. ....
Kind of prime movers ....
Condensing or non-condensing ....
How many air compressors ....
Cubic feet capacity each ....
Total cubic feet air compressor capacity ....
Total cubic feet air compressor capacity operated on day shift.............
How are compressors driven:
(a) Steam
(b) Electricity
(c) What pressure air carried ....
Have you high pressure water line for testing boilers operated from main power plant ....If so, how controlled to start and stop ....
Are boilers equipped with stokers .... If so, what kind ....
What kind of fuel ....
Feed water heaters ....
Source of water supply ....
Storage capacity of water ....
What voltage of shop motors ....
What voltage on distribution line ....
Kind of stack ....
Size of stack ....
Natural or forced draft ....
Coal handling machinery ....
Ash handling machinery ....
Are there special high pressure boilers to supply steam to test boilers without firing up in boiler and erecting shop ....

Stores Department

Where is the main store building located with respect to machine shop......
Does a yard crane pass over store casting platform......................
Does this same crane deliver materials to machine shop door..............
Are gasoline tractors or electric trucks and trailers used for material delivery ....
Is the stores delivery system under supervision of Stores Department or Mechanical Department ....
Are there sub-stores located in shops for distribution of small parts, such as rivets, bolts, nuts, washers, etc. ....
Who writes material requisitions ....
How are they transmitted to storekeeper................................
Are materials kept on hand so that all materials can be ordered as engines are stripped ....
Are any finished sets of materials kept in shop stock account for expediting repairs to locomotives ....
Are spare boilers or back ends kept in stock to facilitate application of fireboxes ....

SHOP MANAGEMENT AND PRACTICES

Do you work piecework in locomotive department ....
Do you have a scheduling or routing system ....
Stripping practice:
(a) Are engines stripped on a specially fitted up stripping track....
(b) Are engines stripped on their assigned pit in erecting shop....

INSPECTION

What system of inspection is employed to ascertain extent of repairs in detail as engine is stripped and parts ordered ....
What inspection is carried on during progress of work ....
Are special gangs organized for each class of work ....
How many pits assigned to one erecting shop gang ....
Where is running shed located ....
How many engines capacity ....
Is counterbalancing checked periodically, if so, when ....
Are boilers tested before removing flues ....
Are boiler fronts removed and front end washed out before engines in erecting shop ....
To what extent are detail costs of repairs kept ....

Appendix C

(3) METHODS FOR THE SAFE AND CONVENIENT STORAGE OF CRUDE AND FUEL OILS

J. M. Metcalf, Chairman, Sub-Committee; C. N. Bainbridge, K. B. Duncan, G. W. Harris, W. H. Kirkbride, F. E. Morrow, D. A. Porter.

(A) OIL PUMPING PLANTS

The Committee's earlier investigation, as reported to the Association in 1924 and printed in the Proceedings for that year (Volume 25, pages 66 to 95), showed that steam driven piston pumps were in general use by oil-burning railroads for pumping oil. There has been since that time an increasing use by some roads of electric driven centrifugal pumps which are considered more economical under certain circumstances.

Among the factors to be considered in determining the economical plant for a particular installation are the following:

(1) Possible Saving in Wages Through Automatic Operation

Where heating requirements permit, the electric driven pump lends itself to automatic operation, requiring daily inspection but no continuous attention. As protection for automatic operation, a pressure tank near the oil column is recommended. Following is description of such a tank in use on one road.

"The tank is air tight, with inlet and output through the same opening in the bottom. When the tank is filled to the one-half or three-quarter point, the pressure gage of Bourdon or diaphragm type breaks the connection and stops the pump. When the oil column is opened, the air pressure expels the oil to the column, and when the pressure drops ten to fifteen pounds, the gage makes connections and starts the pumps. If the oil column is pulled over, electric connection at the column is broken and a gate valve on outlet pipe, which is held open by a magnet, drops by gravity and shuts off the oil. The pressure or surge tank should be large enough to avoid injurious starting and stopping of the electric equipment. As a further fire protection, the pressure tank is placed in a concrete pit of capacity equal to that of the tank, and collects all leakage. The safety valve on the pressure tank should be placed below the oil line to avoid trouble from air leaks."

(2) Delivery by Gravity or Under Direct Pump Pressure

Where delivery is direct from pump to oil column, requiring continuous power service, the electric driven pump automatically operated has advantages over the steam plant in reduced power requirement. Where pumping is into storage or delivery tank and may be performed at convenience of an operator who is otherwise employed, the less expensive installation of steam plant may be found more economical.

(3) Heating Requirements

Necessity for providing high pressure steam at pump house for heating purposes, with continuous supervision while pumping, has often been a determining factor in favor of the steam plant. Where oil can be kept at required temperature with an automatic low pressure heating system, or where no heat is required during a considerable portion of the year, making attendance to supervise heating unnecessary, the automatically operated electric pump may prove economical. Possible use of exhaust steam from pump for heating should be considered.

(4) Available Power

Comparative economy of electric operation may depend on power requirements at the terminal for other purposes, and on the availability of steam, when required for heating, from a central plant, making an independent boiler at the oil station unnecessary.

(5) Suction Level

It may be desired to move some fuel oil before it is warmed or the oil may become too hot and be inclined to gas. To meet these conditions, fuel pumps should be set as close to the surface of the oil as practicable, and provided with a suction line large enough to allow cold oil to flow to the pump. It is recommended that fuel pumps be set so that they will at all times be flooded. If a suction lift is used, the more efficient suction of the piston pump gives better results.

(B) FIRE PROTECTION

The Committee recommends that paragraph 5 of conclusions adopted for printing in the Manual, as printed in Supplement to 1921 Manual, Bulletin No. 278, page 83, be revised to read as follows (new matter underlined):

Oil should be unloaded from tank cars by discharging direct into a trough or boxes of steel or concrete between the rails of track on which cars stand for unloading. Where boxes are used, they should be spaced at car-length intervals for convenience in spotting cars for unloading. Troughs or boxes should be equipped with metal covers, kept closed when not in use. The unloading facilities should be located on a track assigned for this purpose, <u>preferably at some distance from buildings or other tracks,</u> and so <u>that it will be unnecessary for locomotives to pass over them. While tank cars are being unloaded, a sign warning against disturbing them should be posted between the first car and the switch.</u>

REPORT OF COMMITTEE XII—RULES AND ORGANIZATION

W. C. Barrett, *Chairman;*
E. H. Barnhart, *Vice-Chairman;*
M. M. Backus,
R. A. Baldwin,
D. P. Beach,
R. G. Bowie,
R. Brooke,
H. L. Browne,
R. Burroughs,
E. N. Burrows,
P. D. Coons,
J. L. Downs,
A. B. Griggs,
E. F. Gorman,
H. H. Harsh,
A. A. Jackson,
J. L. Jamieson,
B. R. Kulp,
W. C. Mack,
R. D. Martin,
H. J. Pfeifer,
R. N. Priest,
R. V. Reamer,
H. D. Sheets,
J. W. Stevens,
R. E. Warden,
W. H. Wheaton,
F. B. Wiegand,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

1. Revision of the Manual.

2. Continue the study and report on rules for the guidance of employees of the Maintenance of Way Department, with special reference to:

   (a) Rules for employees who operate and maintain motor cars (Appendix A).
   (b) Rules for maintenance of buildings (Appendix B).
   (c) Rules for maintenance of bridges.
   (d) Rules for maintenance of other terminal structures (Appendix C).

3. Continue the study of titles below rank of Division Engineer, which are employed to designate positions of corresponding rank in maintenance of way service, and make recommendations that will promote uniformity in nomenclature (Appendix D).

4. Prepare rules for fire prevention as applying to railway property (Appendix E).

Action Recommended

1. Inasmuch as the present Manual has been carefully studied this year by your Committee in connection with the re-writing and publishing, which will doubtless be completed prior to the March, 1929, meeting of the American Railway Engineering Association, it is not felt proper to suggest any further revision.

2. (a) The Committee offers for approval and printing in the Manual as an addition to the "Manual of Rules for the Guidance of Employees of

Bulletin 311, November, 1928.

the Maintenance of Way Department," Rule 297, in Appendix A, to be included under "Rules for the Operation of Motor, Hand, Velocipede and Push Cars."

The Committee also offers for approval and printing in the Manual as additions to the "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department," Rules 651, 661 and 692 in Appendix A.

(b) The Committee offers for approval and printing in the Manual as part of the "Manual of Rules for the Guidance of Employees of the Maintenance of Way Department," the rules found in Appendix B.

(c) The Committee reports progress on this assignment but is not yet ready to submit report on subject assigned.

(d) The Committee report on this assignment is found in Appendix C and is submitted as information only.

3. The Committee recommends the adoption of titles shown in Appendix D to promote uniformity in nomenclature.

4. The Committee report on this assignment is found in Appendix E and is submitted as information only.

Recommendation for Future Work

1. Revision of the Manual, making a study of the subject-matter of each standing committee, distinguishing where necessary between rules and specifications, abstracting therefrom such material as may be suitable for rules, collaborating with standing committees concerned therewith.

2. Continue the study and report on rules for the guidance of employees of the Maintenance of Way Department, with special reference to:

- (a) Rules for maintenance of bridges.
- (b) Rules for maintenance of other terminal structures.
- (c) Rules for maintenance of telegraph and telephone lines and appurtenances.

3. Continue the study of titles below rank of Division Engineer, which are employed to designate positions of corresponding rank in maintenance of way service and make recommendations that will promote uniformity in nomenclature.

4. Continue preparation of rules for fire prevention as applying to railway property.

5. Outline of work for ensuing year.

Appendix A

(2-a) RULES FOR EMPLOYEES WHO OPERATE AND MAINTAIN MOTOR CARS

E. H. Barnhart, Chairman, Sub-Committee.

(Prepared by Committee XXII—Economics of Railway Labor)

Rules 297. If car is started with a crank, it must be pulled upward holding thumb against forefinger when the charge is being compressed in the cylinder, to avoid injury to the person cranking the car in case the engine should backfire.

RULES FOR CONDUCT OF WORK

M. M. Backus, Chairman, Sub-Committee.

(From material prepared by Committee I—Roadway)

Rule 651. Borrow pits or low spots must be drained or filled.

Rule 661. Rough ground (or surplus ditching material) must be smoothed to permit use of mower.

Rule 692. Material taken from cuts or from right-of-way along embankment for general widening or for other purposes, must be so handled that both the place from which it is taken and the place where used will be finished in a workmanlike manner and leave the surface smooth and of good appearance.

Appendix B

(2-b) RULES FOR EMPLOYEES OF THE BUILDINGS DEPARTMENT

B. R. Kulp, Chairman, Sub-Committee.

(Prepared in collaboration with Committee VI—Buildings)

Construction

1661. Whenever practicable, buildings must be located on outside of curves and far enough from road crossings to avoid obstructing the view of trainmen or of travelers on the highway.

1662. Local laws and permits required by municipalities must be complied with and all necessary permits must be obtained.

1663. Alterations or additions not covered by plans must conform as nearly as possible in appearance to the main building to which they are attached.

1664. Proper authority must be obtained before the construction of any building.

1665. Work in progress must always be kept safe for trains, the public and for employees. Each piece of work must be completed before going to another, except in case of emergency.

1666. High platforms and buildings on timber foundations must be enclosed to prevent accumulation of paper, rubbish, scrap, etc.

Maintenance

1668. Cornices, gutters, downspouts, and other places of lodgment must be kept free of obstructions.

1669. Maintenance of all portions of buildings and structures not easily accessible, such as roof trusses, rods, cornices, under supports, gutters, downspouts, inside posts and braces, must be given special attention.

1670. Report must be promptly submitted to proper official covering buildings on property leased from the Railroad and owned by outside parties, that are not properly maintained or painted.

1671. In order that the insurance schedule may be kept up-to-date all changes, either in renewals or repairs, which may in any way affect the value of the building or structure, must be reported through the proper channels.

1672. If a building or other structure is burned or damaged, an inspection and report must be made as soon as possible, giving the nature and extent of the damage, with an estimate of the cost of repairs.

1673. Foremen in charge of work must supervise the construction of scaffolding to see that it is safe.

Construction and Maintenance

1674. The date of erecting and painting of all buildings must be plainly indicated on the structure in an inconspicuous place and preferably covered for weather protection.

1675. In constructing and maintaining buildings and platforms, careful consideration must be given to proper drainage, to permanent alignment and grade of tracks, to public improvements and to future changes.

1676. Buildings and other structures must be constructed and maintained with standard clearances. Special authority must be obtained to vary therefrom.

1677. Main line passenger and freight platforms built new, must be located with reference to track and in accordance with standard plans, and old platforms changed or renewed must be brought to standard where practicable.

1678. Runways or ladders must not be located under scaffolds, or at other points where tools or material are likely to fall, and where a considerable amount of work is in progress barricades must be erected.

1679. Rope and tackle scaffolds which have been stored or shipped must be thoroughly tested for deterioration or injury before being used.

1680. Bulletin boards must be provided in or around completed structures for the posting of notices.

1681. Station signs must be placed in conformity with the prescribed standards and maintained in good condition.

Appendix C

(2-d) RULES FOR MAINTENANCE OF OTHER TERMINAL STRUCTURES

A. B. Griggs, Chairman, Sub-Committee.

(Submitted as information only)

Oil Houses

(1) Oil storage facilities must be kept thoroughly grounded at all times and maintained in such a way that all pipes and connections will be tight.

Coaling Stations

(1) Special attention must be given to maintenance of bins, chutes and working appurtenances of all coaling stations.

(2) Inspection must be made from time to time and corrective measures taken to keep shed free from dirt, coal dust or screenings.

Ash Pits

(1) Where brick or concrete materials form any part of support of track over pit, particular attention must be given to the maintenance of these pits.

(2) Steel beams supporting tracks must be watched to see that the hot cinders have no effect on their strength and the rail fastenings kept in proper order.

(3) Water supply must be maintained at all times and strict supervision maintained to see that cinders dumped from locomotives are immediately wet down to keep the heat away from side walls and track supports.

(4) Drainage must be looked after frequently to see that catch basins are cleaned out to prevent ashes from being washed into the sewer.

Turntables

(1) All refuse and dirt must be kept off the deck and out of the pit at all times.

(2) Center bearing of turntables must be kept clean, properly lubricated and in good working condition. At certain intervals turntables must be jacked up so as to make careful examination of center, at which time it must be cleaned and thoroughly lubricated.

(3) Top flanges and cross bracing of turntables must be kept clean and when tie renewals are made top flanges given a coat of paint. At proper intervals entire table should be cleaned and painted with approved structural steel paint.

(4) Inspection of and maintenance of turntables must not be undertaken without first notifying the operator.

(5) In severe weather fires must not be built around turntables in such a manner as to damage the steel structures, to assist in turning. Where heat is necessary steam connections must be used when available.

Track Scales

(1) All track scales must be numbered and referred to by number and location.

(2) Extensive repairs to scales, such as renewal of or sharpening of pivots, should be made in a properly appointed shop.

(3) When scales are in service regularly, scale parts, substructure and foundation must be cleaned at least twice a month. Exposed parts so located that they are liable to become clogged with ice or dirt, must be cleaned more often.

(4) The best rust preventatives obtainable must be applied to pivot and heavy steel bearings in such a manner as not to interfere with the proper working of the scale.

(5) Salt must not be used around scales. Artificial heat should be used.

(6) Equipment must not be allowed to stand on the scales except when being weighed.

(7) Engines or similar heavy equipmust must not be passed over the live rails.

(8) Cars on the live rails must not be moved by cars or engines on the dead rails, or vice versa. Cars must not be moved over the scales with one truck on the live rails and another truck on the dead rails. Cars must not be stopped on the scale by impact, by the sudden application of brakes or throwing obstructions under the wheels.

(9) Sand must not be applied or injector used when on the scale. The slipping of engine drivers on either live or dead rails is injurious to the structure and must be avoided.

(10) The weigh beams should be balanced before the scale is used; when not in use, should be secured by the beam catch and with the poise set at the highest graduation.

(11) Scale houses and beam boxes must be kept locked when not in use.

(12) Where compressed air facilities are available provision must be made for loose hose connection so that dust and dirt can be blown off the scale.

(13) Where compressed air facilities are not available provisions must be made for the connections with weigh engines for blowing dust and dirt from scales.

Appendix D

(3) STUDY OF TITLES BELOW RANK OF DIVISION ENGINEER, WHICH ARE EMPLOYED TO DESIGNATE POSITIONS OF CORRESPONDING RANK IN MAINTENANCE OF WAY SERVICE AND RECOMMENDATIONS THAT WILL PROMOTE UNIFORMITY IN NOMENCLATURE

H. H. Harsh, Chairman, Sub-Committee.

(Summary of replies to questionnaire sent sixty-six railways)

1. Division Engineer is title of chief maintenance officer on Division.
2. Supervisor of Bridges and Buildings is the title assigned to the supervisory officer responsible for maintenance of bridges, buildings and structures.
3. Supervisor of Water Service is the title assigned to the supervisory officer responsible for maintenance of water service.
4. Supervisor of Signals is the title assigned to the supervisory officer responsible for maintenance of signals.
5. Supervisor of Telegraph and Telephones is the title assigned to the supervisory officer responsible for maintenance of telegraph and telephones.
6. Supervisor of Track is the title assigned to the supervisory officer responsible for maintenance of track.
7. Supervisor of Work Equipment is the title assigned to the supervisory officer responsible for work equipment.

The Committee recommends the above titles be adopted to promote uniformity in nomenclature of maintenance titles.

Appendix E

(4) RULES FOR FIRE PREVENTION IN RAILWAY TERMINALS

W. C. Mack, Chairman, Sub-Committee.

(Approved by Committee XXIII—Shops and Locomotive Terminals)

The Committee expresses appreciation for the assistance given by the Railway Fire Protection Association on this subject.

(Submitted as information only)

Fire Protection Begins With Proper Design of Terminal

(1) The terminal must be designed with sufficient fire roads, crossing as few tracks as possible. Fire roads must be easily accessible to any municipal fire equipment and so located that all structures will be on or adjacent to fire roads. They must be designed with easy turns permitting rapid movement of motorized equipment.

(2) In locating facilities within the terminal, consideration must be given to hazard from adjacent burning property.

(3) Structures must be placed as far apart as their design and use will permit, segregating those with greater fire hazard and locating all in a manner which will permit isolation and prompt quenching of fires. Fire risk in important structures must be subdivided into distinct areas by fire walls, where practicable.

(4) Temporary housing facilities, often erected during abnormal labor conditions, or recreation or reading rooms must not expose valuable or essential structures to undue fire hazard. Clear exit passages inside and unobstructed passage space outside must be provided for these structures.

(5) Lumber and tie storage yards must be placed at least one hundred feet from all important structures and a safe distance from all tracks where engines are operated frequently. Yards must contain clear spaces one to two hundred feet wide to divide the yard into distinct fire areas. In congested areas where impracticable to provide clear spaces of the width desired a number of water monitors may be concentrated on a certain area of material, which, when drenched, will provide a substitute fire break. Adequate clearance must be provided around fire hydrants and water monitors to insure against interruption of their operation in event of fire.

(6) Cotton storage sheds must be located at least eighty feet from any other structure or frequently used streets or highways and must be located to avoid, as much as possible, hazard from locomotive sparks.

(7) Coal storage sites must be well drained and free from exposure to any external heat. Sufficient area must be provided to accommodate volume necessary without piling coal more than twelve feet high.

(8) Oil storage tanks and structures containing other inflammables or explosives must be located, installed and protected according to the regulations of the Railway Fire Protection Association and the National Board of Underwriters.

(9) Viaducts with long wooden roadways must be provided with roadway panels of fireproof material at intervals sufficient to prevent fire traveling entire floor of structure. In important structures it may be desirable to provide a pipe line which can be used as a water main during fire.

(10) Pipe lines must be of loop or grid design with adequate size main, with valves located to by-pass any rupture of the line. This system must be connected to a municipal water supply where available. Hydrants and outside stand pipes must be easily accessible from the fire roads, with hydrants located not less than fifty feet from any structure. All hydrants must be two way with standard connections. Where motor fire trucks are used it may be desirable to have hydrants equipped with steamer connections.

(11) The terminal must include storage tanks of sufficient capacity to insure adequate water supply to quench the largest fire possible on the property. An elevated tank of 100,000 gallons, or more capacity, constructed to a height of 100 feet to the underside of tank, gives reasonable working pressure at all times. To insure adequate pressure the water lines from the tanks must be so arranged that they may be directly connected for fire fighting purposes with an approved fire pump of sufficient capacity. Structure housing fire pump must be fireproof and isolated from other structures.

(12) The terminal must include sufficient hose cart houses, hose carts and other equipment easily accessible to fire roads and hydrants. Hose carts, properly housed and equipped, must be located to cover definite areas and be available for reinforcing any unit in case of fire. Hose houses of standard mill yard type must be located over hydrants with hose attached to hydrants and controlled by independent cut-off valve where protecting congested districts or structures of large value.

(13) The design must include an automatic fire alarm system for all structures or a manually operated system with boxes so located that it should not be necessary to travel over two hundred feet to register an alarm. When permissible a non-interfering system if used must be hooked into the city fire alarm system; if any other system, it must be connected through a master box to the city fire alarm. The local alarm must be connected to and automatically sound in code a siren to indicate the location of the alarm.

(14) In certain classes of railroad structures where large values in buildings exist and often greater values in contents are subject to fire loss, approved automatic sprinkler system must be installed.

REPORT OF COMMITTEE XIV—YARDS AND TERMINALS

J. E. ARMSTRONG, *Chairman;*
J. R. W. AMBROSE,
IRVING ANDERSON,
C. E. ARMSTRONG,
H. M. BASSETT,
E. J. BEUGLER,
C. H. BLACKMAN,
ALFRED BOUSFIELD,
N. C. L. BROWN,
H. F. BURCH,
W. A. CHRISTIAN,
C. H. CRAWFORD,
D. T. CRAWFORD,
A. W. EPRIGHT,
E. H. FRITCH,
JOHN V. HANNA,
R. J. HAMMOND,
M. J. J. HARRISON,
E. M. HASTINGS,
H. L. RIPLEY, *Vice-Chairman;*
H. O. HEM,
*D. B. JOHNSTON,
E. K. LAWRENCE,
L. L. LYFORD,
C. P. MCCAUSLAND,
A. MONTZHEIMER,
C. H. MOTTIER,
H. M. ROESER,
W. B. RUDD,
H. R. SAUNDERS,
V. I. SMART,
C. U. SMITH,
M. H. STARR,
E. E. R. TRATMAN,
I. D. WATERMAN,
A. P. WENZELL,
J. G. WISHART,
J. L. WILKES,

Committee.

*Died November 28, 1928.

To the American Railway Engineering Association:

Your Committee on Yards and Terminals submits reports on the following subjects:

1. Revision of the Manual (Appendix A).

2. Design and Operation of Passenger Terminals, with particular reference to convenience and economy of operation of coach yards (Appendix B).

3. Collaboration with Committee XX—Uniform General Contract Forms on "Form of Agreement for Joint Ownership, Use and Management of a Terminal Project." The Committee reports progress on this assignment.

4. Design and Operation of Freight Terminals with particular reference to Car-to-Car Transfer Through L.C.L. Freight (Appendix C).

5. Scales (Appendix D).

6. Practical Design and Construction of Humps in Terminal Yards. The Committee is analyzing information it has obtained and will make a verbal progress report at the March convention.

Action Recommended

1. That the revisions in Appendix A be approved.

2. That the recommendations on Design and Operation of Passenger Terminals be approved for publication in the Manual.

Bulletin 312, December, 1928.
A

4. That the report on Design and Operation of Freight Terminals with particular reference to Car-to-Car Transfer Through L.C.L. Freight be received as information.

5. That the report on Scales be received as information.

Recommendations for Future Work

1. Revision of Manual.
2. Continue study of design of passenger terminals, with particular reference to convenience and economy of operation of coach yards, collaborating with Committees on Shops and Locomotive Terminals, Water Service and Sanitation, and Joint Committee on Railway Sanitation.
3. Collaborate with Committee on Uniform General Contract Forms in the preparation of "Form of Agreement for Joint Ownership, Use and Management of a Terminal Project," giving special consideration to fundamental requirements.
4. Study and report on provisions for parking and garage facilities for private automobiles of railway passengers at passenger terminals and way stations.
5. Continue study of design and operation of freight terminals.
6. Continue study of proper requirements for practical design and construction of Hump Layouts, collaborating with Committee on Economics of Railway Operation.
7. Study and report on co-ordination of facilities at rail and water terminals.
8. Continue study of specifications for various types of scales used in railway service.
9. Outline of work for ensuing year.

Daniel Bird Johnston

Died November 28, 1928

D. B. Johnston, Assistant Engineer Maintenance of Way, The Pennsylvania Railroad, was a valued and active member of the Committee on Yards and Terminals for many years. His wise counsel and good judgment were material factors in the work of the Committee.

His untimely death is deeply mourned by his associates.

Respectfully submitted,

The Committee on Yards and Terminals,

J. E. Armstrong, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

J. E. Armstrong, Chairman, Sub-Committee; H. L. Ripley, Irving Anderson, E. H. Fritch, M. J. J. Harrison, L. L. Lyford, V. I. Smart, E. E. R. Tratman.

Your Committee offers the changes set forth in Appendix D, relating to Scales, for approval and substitution for the corresponding material in the present Manual.

Appendix B

(2) DESIGN OF COACH YARDS

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In designing a coach yard, the most important item is its location with reference to the passenger station and correlated facilities. The coach yard should be close to the station to save dead mileage. The cleaning and servicing of baggage, mail, express and passenger equipment is best performed close to the engine house and shop facilities, for two reasons: First, to hold at a minimum the movement of power between the engine house and train; second, to have convenient facilities, without duplication, for maintenance of equipment.

Others factors entering into the location of a coach yard are land values, available sites, cost of construction, convenience to the station and working agreements with train and enginemen. After making comparisons of sites for convenience, and co-ordination with other facilities, the problem becomes one of comparing the cost of moving trains between the station and coach yard with the cost of providing an adequate facility at different locations. Some railway companies have working agreements which allow handling of trains in the terminal with road crews, while on other railways terminal movement must be made by switching crews.

The required capacity of a coach yard depends upon the number of cars and trains to be handled, class of trains, standard of maintenance, length of layover, and frequency with which the cars are subject to complete cleaning and servicing.

Cars on short runs and receiving frequent cleaning require less time than cars on long runs of several days' duration. It is common practice to hold trains for cleaning and waiting on one track where the waiting period is less than 24 hours. Since for any terminal the waiting periods and class of equipment are quite variable, and the amount of time required for cleaning and servicing is different, the capacity required is a problem peculiar to that terminal.

A questionnaire was sent to all railways represented in this Association, and this report is based on the returns from twenty-eight railways reporting on thirty-one different coach yards. This report deals primarily with coach yard facilities for handling through passenger equipment, some of which may not be necessary for handling suburban equipment.

Cars vary in length from 55 to 85 feet. In a majority of coach yards examined, tracks were assigned to individual trains both for cleaning and holding where the time was less than 24 hours. This method has developed through the desire to reduce switching. The average time for all cars remaining in various coach yards ranged from 3½ to 14⅔ hours, and the average of the averages was 8.1 hours.

Additional tracks for storage required in any yard to take care of surplus equipment during periods of light traffic, or accumulation of equipment for excursions and special trains, depend upon the business of the individual road.

Where the daily average number of cars handled regularly through the coach yard was greater than the standing capacity of the tracks, the reports generally indicated that the yard was considered inadequate by the operator. These conclusions are justified by the fact that trains arrive and depart in fleets and are held for cleaning and waiting on one track. Of yards that were reported inadequate several were handling twice as many cars as the standard capacity of the yard. In some of these instances a substantial amount of extra switching was required which might justify an expansion of facilities.

The two general types of coach yard layouts are those made up of stub tracks and through tracks. There is an intermediate type made up of through tracks but operated generally as two systems of stub tracks; this has some advantages from a switching standpoint. The stub type of yard lends itself most readily to irregular pieces of ground which may be very conveniently located with respect to the station and not suitable for other types of track layouts.

Cars placed on stub tracks are easily accessible from the stub end for employees and trucks, and this arrangement provides safety to employees by avoiding the crossing of tracks. Employees are also not endangered by the movements of cars in the yards. Switching is less efficiently handled in a system of stub tracks than in a system of through tracks.

Reduction of switching is the chief object in the selection of length of tracks in a coach yard. The tracks may be of equal or variable length. The longest tracks should be as long as the longest trains. Where trains are broken up for cleaning, the cars may be placed on tracks of equal length; but where trains are not broken up for cleaning, which is the usual case, tracks of equal length would not be filled with trains of variable length. Tracks of variable length will best accommodate the general run of trains in large stations, but the greatest operating efficiency is obtained with tracks of equal length, allowing any train to be placed on any track. In a yard of the double stub type, tracks should be as long as two trains, with a passageway for employees and trucks across the middle.

Spaces between tracks are occupied by ladders, scaffolds, ice carts, hose carts, two-wheel trucks, cleaning apparatus on wheels, air testing apparatus on wheels, etc. Tracks should be spaced far enough apart to allow free movement of employees with trucks. Some layouts have been made with wide and narrow spaces alternating in order to save space, the wide space being used for operation of trucks, ice carts, etc. The equal spacing of tracks, with each space sufficiently wide to permit the operation of all cleaning equipment, provides the greatest flexibility of operation. Track spacing varies from 13 to 22 feet. A spacing of 18 feet between centers of tracks has proven ample and where land values are high this may be reduced to 16 feet or to alternate spacing of 14 and 16.

The tracks should be arranged in groups at the lead so that switching may be carried on by as many engines as needed. Auxiliary leads should be arranged to provide prompt entrance and exit for each group of tracks, with tail tracks ample to permit handling the longest cuts of cars. Nothing sharper than a No. 8 turnout should be used, but instances will occur in which easier turnouts are possible and advisable. The gradient of coach yard tracks should preferably be level, but in no event should it exceed 0.3 per cent.

A wye or loop track is highly desirable for turning equipment. If space is available for a loop, that arrangement is superior to a wye, since a train makes the complete turn without operating intermediate switches or stopping to reverse its direction. Individual cars may be turned on a turntable if it is conveniently located.

Special tracks for making-up and breaking-up trains are sometimes required. When a train is made up from stored equipment, or when special trains are broken up for storing, it may not be possible to do the work on tracks regularly assigned to other trains. The work required on these trains may be done ordinarily at off-peak periods when the tracks assigned to regular trains are not occupied.

Only light or running repairs are made in a coach yard. As some repairs may require cars to be set on special repair tracks, such tracks should be provided, and so arranged, that cars can be switched to them without delay.

The track-bed and platform-bed in coach yards should be well-drained, in view of the large amount of water used in washing coaches. Practice has not developed any special type of track construction; usual track standards being followed.

Platforms should be placed between all tracks to provide roadways for employees and trucks and to promote sanitary conditions. Wood, brick and bituminous compounds are used as platform material, but are not cleaned as easily nor maintained as readily as is concrete, which is being used extensively in modern construction. The height of platforms varies from the base of rail to six inches above the top of rail. The recommended height is the top of rail, as this gives good drainage and facilitates extension of the platform across the tracks and will not interfere with work of car mechanics. A gutter leading to sewer inlets and arranged to catch surface drainage from the track as well as from the platform should be placed along each edge of the platform. The edge of the platforms should be 5 feet 6 inches from the center of the track to allow drippings from the sides of the cars to fall in the gutter. The platform should be crowned $\frac{3}{16}$ inch to the foot to promote good drainage.

Platform service for drinking water, wash water, compressed air, vacuum cleaning, electricity and steam should be provided at spacings close enough to prevent delays in servicing cars.

Drinking water and cold wash water are usually from the same supply, but if separate supplies are required, they should be parallel systems, since the demand is nearly the same for each car. Hydrants should be placed a minimum distance apart equivalent to the average length of cars. Usual practice is to have these hydrants in alternate spaces between tracks. However, there are substantial advantages in locating hydrants between all tracks. Committee XIII—Water Service, Vol. 29, page 158, has reported on the type of hydrant box to provide protection from frost and to prevent obstruction on the platform. Hot water is not usually provided through pipes, but in tanks or tubs at convenient locations where it is heated with steam.

Compressed air is used for two purposes: cleaning car interiors and testing air brakes. For cleaning, supply connection should be provided the same as for cold water. For testing air brakes, supply connections should be provided through a double connection at the center of each track or through single connections at each end of each track.

Where vacuum is used for cleaning and is produced by a central plant, the supply connections should be spaced at the same intervals as the air supply connections. In some coach yards cleaning is done with portable vacuum apparatus.

Electrical supply connections to be used for charging batteries that are not removed from the cars and for operating portable vacuum machines should be placed a minimum distance apart, equivalent to the average length of two cars. It is usual practice for these to be placed in alternate spaces between tracks, but there is substantial advantage to have them placed in all spaces between tracks, which may be economical on account of the possibility of only a few connections being placed on each circuit. When these connections are placed in alternate spaces between tracks, at least four sockets are required at each connection.

Steam supply connections for the purpose of heating cars should be provided in the same manner as connections for air for testing air brakes.

A service building should be constructed adjacent to the coach yard, in such position that movements of workmen between it and the work will be a minimum average distance. This building should contain a foreman's office and lavatories, toilets, locker and lunch rooms for employees, battery charging and repair room, oil room, ice storage bin, supply room for workmen, car mechanics shop and supply room, fuel supply for coaches and supply room for fixtures. For the Pullman Company there should be an office, a shop for fixture repairs and space to store supplies and fixtures. Adjacent to these facilities a platform should be provided for cleaning carpets of the size used in cars.

If the coach yard facilities are not located near a general storehouse, there should be a storehouse maintained to carry sufficient supplies to meet current needs.

At least one drop pit, serving two tracks, should be provided in large yards, so that one will be available for emergency changing of wheels; the number of pits to be determined by the business handled. Car hoists are used in some instances. Inspection pits are a great advantage to repair tracks, so that running-gear can be thoroughly inspected.

Provision should be made to store a sufficient number of car wheels, depending on the demand at any particular yard. There should be a building, providing space for the necessary shop facilities.

The servicing of dining cars requires the use of every function of the coach yard and additional service for their particular needs. After these cars are cleaned they must be stocked from a commissary, which may be located in the coach yard or at the station.

All refuse about the yard should be gathered frequently and placed in cans or boxes with self-closing covers to prevent ignition. It should be disposed of regularly by removal to a disposal plant or an incinerator.

For fire protection water hydrants and fire hose should be located so that all points in the yard may be reached. Chemical extinguishers should be placed where they can be reached quickly as first aid to quench fires started by oil or electricity.

In order to obtain efficient and safe operation at night, the yard should be equipped with a system of flood lights.

A mechanical car washing plant has recently been developed, as referred to in the *Railway Age*.

Should the use of this form of equipment become general, consideration should be given to its effect upon the arrangement of the yard and the facilities required.

Conclusions

(1) The coach yard should be placed convenient to the station and mechanical facilities.

(2) The location of a coach yard should be determined by the economic balance between the following factors:

- (a) Available sites.
- (b) Land values.
- (c) Cost of construction.
- (d) Convenience to the station and other facilities.

(e) Cost of moving equipment between station, coach yard and engine house.

(3) The capacity required in a coach yard depends upon:

(a) Number of cars and trains to be handled.

(b) Class of equipment.

(c) Standard of maintenance.

(d) Length of layover.

(e) Frequency of cleaning.

(4) It is common practice to hold trains for cleaning and waiting for less than 24 hours on one track.

(5) There are two general types of coach yard layouts: Stub track and through track. There is also an intermediate type made up of through tracks, but operated generally as two systems of stub tracks. Operation is most efficient in a system of through tracks.

(6) Tracks of equal length and equal to the length of the longest trains give greatest operating efficiency.

(7) A spacing of eighteen feet between track centers has proven ample. Where land values are high, spacing may be reduced to 16 feet or to alternate spacing of 14 and 16 feet.

(8) Tracks should be arranged in groups at the leads to facilitate switching. Auxiliary leads and tail tracks of ample length should be provided.

(9) Nothing sharper than a No. 8 turnout should be used.

(10) The gradient of coach yard tracks preferably should be level, but in no event should it exceed three-tenths per cent.

(11) A wye or loop track should be provided for turning equipment. A loop track is more efficient but requires more space.

(12) Special tracks for making-up or breaking-up trains are sometimes required.

(13) Only light or running repairs are made in a coach yard.

(14) The track-bed and platform-bed in coach yards should be well drained.

(15) Platforms should be placed between all tracks.

(16) The platform should be even in height with the top of rail. The edge of the platform should be five feet six inches from the center of the track. The platform should be crowned $\frac{3}{16}$ inch to the foot.

(17) Water hydrants should be placed a minimum distance apart equivalent to the average length of cars. Usual practice is to place these in alternate spaces between tracks. However, there is substantial advantage in locating them between all tracks.

(18) Hot water is usually provided in tubs at convenient locations.

(19) Air connections for cleaning should be spaced the same as cold water hydrants; for testing air brakes, connections should be provided through a double connection at the center of each track or through single connections at each end of each track.

(20) Electrical supply connections should be spaced the same as water

hydrants, but a minimum distance apart equivalent to twice the average length of cars.

(21) Steam supply connections should be provided in the same manner as air connections for testing air brakes.

(22) A service building and storehouse should be provided.

(23) At least one drop pit, serving two tracks, should be provided in large yards.

(24) Provision should be made to store a sufficient number of car wheels.

(25) There should be a building providing space for the necessary shop facilities.

(26) Refuse disposal, fire protection and flood lighting should be provided.

Appendix C

(4) DESIGN AND OPERATION OF FACILITIES FOR CAR-TO-CAR TRANSFER OF LCL FREIGHT

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Car-to-car transfer of freight is brought about largely by the practice of railways delivering through LCL shipments to each other by means of cars, and the practice of manufacturing plants, industries, large mail-order houses, etc., consolidating LCL shipments into cars and delivering them to railways for rehandling into direct-to-destination cars. There is a present tendency to use motor trucks instead of freight cars for making deliveries to the railways and for transferring LCL freight, and this may have an effect on the further development of car-to-car transfer.

The growth of cities with the growth in freight business, and the demand for fast freight service in recent years has brought about the revamping of the freight facilities in many large cities. This situation has brought to the attention of engineers and of operating officials the possibility of providing separate car-to-car transfer LCL facilities outside of the city limits. In some large cities, freight yards that previously were located near the center of the city have been re-located at a considerable distance from the city and are now connected by belt lines. The tendency is to divert all freight shipments not consigned for the city, around it via the belt line. If such an arrangement is in effect, it is possible that a car-to-car transfer can be maintained to good advantage. Other things being equal, however, there must be a large number of such LCL transfer cars to justify such an arrangement. Generally, each individual road has one or more local LCL freight stations that justify the operation of a freight station capable of loading direct to destination quite a number of LCL cars. If the road maintains in addition to the local LCL stations, an outlying car-to-car transfer, more cars will be required to handle the same volume of business than if the two facilities were consolidated in one. The consolidation also results, other things being equal, in a heavier loading of cars and in the loading of more direct-to-destination cars. If two facilities are maintained and the same volume of business is handled, delays will result by having to handle certain freight from the car-to-car transfer to the freight house on account of no destination cars for certain shipments being available at the car-to-car transfer, or vice versa.

One of the main factors to consider in determining whether an independent car-to-car transfer should be provided is the possible effect on delay to freight and the more complete "schedule" of cars than is possible in the consolidated station. The effect of each of the two alternate methods of handling on the traffic possibility of the road must receive careful consideration. The effect of car haul on the two methods will differ in each problem and must be considered carefully.

Frequently, the available sites in the city, where the local LCL freight facilities are provided, are such that they cannot be expanded, or the land values are so high that the outlying car-to-car transfer is the solution. In such cases, however, the availability of the labor supply and the effect of two separate labor units on the economics of the handling of the freight must be given full consideration.

In recent years, a very large car-to-car transfer has been provided by one western road, to make possible the consolidation of freight from several of its local LCL freight stations and from connecting lines. In this particular case it is estimated that economies will be effected by the use of less cars and in the loading of more direct-to-destination cars. Against this must be figured the cost of the increased investment and the increased handling at the local and the car-to-car transfer stations. The saving of re-handling at break-bulk points will tend to offset the increased costs at the local and the car-to-car transfer stations.

If it is more economical to handle the car-to-car transfer at the local freight station, the problem, so far as operation and design are concerned, can be analyzed along the lines that are covered fully in the report of this Committee, contained on pages 662-716 of Vol. 26. If exclusively car-to-car transfer facilities are to be provided, the requirements of each individual case will have to be considered carefully, and the facilities that will permit of the handling required with minimum trucking and switching costs will be the most desirable. The method of analysis outlined in the report of the Committee, to which previous reference has been made, will in a large measure, serve in making such a study.

With a view of determining the extent to which car-to-car transfer facilities have been provided, a questionnaire was sent to the principal railways of United States and Canada, requesting the number of such facilities in operation. Railway companies, representing approximately 160,000 miles replied. The replies indicated that the roads covering 55 per cent of the mileage reported do not maintain separate car-to-car facilities. On the remaining 45 per cent of the mileage, a total of 31 separate transfer facilities are maintained. The questionnaire developed that a railway serving a few cities and towns within the Boston Metropolitan District, the LCL freight which was formerly loaded into cars at those points and brought into Boston for transfer to through outbound cars, is now handled from those points to Boston by motor trucks. The justification for this handling is in the time saved in moving merchandise from the outlying cities to the main freight house, at no increase in transportation cost. Reference to a few facilities will indicate methods used by some roads to accomplish the car-to-car transfer.

Chicago, Rock Island & Pacific Railway Company.—At Chicago, this road has maintained for a number of years, a separate transfer facility in each of two yards where it transfers LCL freight received from and delivered to connecting lines, each transfer operating independently and handling cars from the railways delivering to that yard.

The transfer facilities at the yard nearest the downtown terminal are located at one end of the yard and opposite the receiving tracks, and consist of a covered platform 700 feet long and 35 feet wide, with tracks to serve. On one side are four tracks connected at each end, on which are spotted 88 empty cars for the outbound loading. On the other side of the platform are two tracks on which are placed loaded cars for transferring. The usual method of operation is to place the cars to be unloaded first, near the center of the string of empty cars and to unload those on the track next to the platform first. These unloaded cars are then switched out and replaced with loaded cars from the second track. In spotting the loaded cars, an effort is made to locate them in such manner that the trucking distance will be as short as possible. This platform handles from 50 to 80 loaded cars per working day and the trucking equipment consists of the ordinary tip-up two-wheel trucks.

The transfer facilities at the outlying freight yard are located at one end of the yard and consist of two platforms with tracks to serve. The platform nearest the yard tracks is 30 feet wide and 950 feet long and has in its center a steel trucking surface 14 feet wide, extending the full length of the platform. On one side of this platform are four tracks on which empty cars are spotted for loading and are set in the most convenient manner for switching to outbound trains. On the other side of the platform is the track on which loaded cars are spotted. Adjacent to this track is another platform 700 feet long and 12 feet wide with a steel trucking surface 28 inches wide, the full length of the platform. On the other side of this platform are two tracks on which loaded cars are spotted for transferring. Both platforms are covered, and at one end are necessary buildings for offices, cooper shops, storage rooms and lunch room.

The equipment used at these platforms consists of four-wheel trucks with tubular pipe frames on the ends, bent to plow handle style. The trucks can be coupled together and are moved by man power in fleets of six to eight. From 60 to 80 cars per day are handled at these two platforms. Some of this freight must be weighed and five scales are spaced equally along the length of the wider platform.

The New York, New Haven and Hartford Railroad Company.—About ten years ago this road constructed at Cedar Hill, New Haven, Conn., a separate transfer facility which probably handles as large a tonnage as any of its kind in the United States. It consists of four platforms, two of wood construction and two of concrete, which will be designated as platforms A, B, C, and D. They are served by a total of sixteen tracks which connect with a lead at each end. There are four tracks on one side of platform A, two tracks between A and B, three tracks between B and C, two tracks between C and D, and five tracks outside of platform D. The platforms are 1200 feet in length and 30 feet in width, except platform B, which is 20 feet in width, and they are protected by roofs with supporting posts along the sides. The transfer facility with its sixteen tracks has a capacity of 416 cars.

The tracks on the outer side of platforms A and D are used for receiving the loaded cars of LCL freight and empty cars are spotted on the tracks between platforms, which places the empty cars on both sides of platforms B and C. Cars are spotted door to door, and three pairs of lift bridges, two near each end and one in the center, have been provided for transfer between platforms. The doorways of the loaded cars adjacent to the platforms are first cleared, after which the gangs entirely unload the cars on the outside tracks. They then return to the cars on the next track, while the cars made empty are removed and the tracks are filled with loaded cars. This replacement of empty cars during the working day is confined to the two outside tracks on each side of the transfer. This occurs at approximately mid-day, about fifteen minutes being required to switch out empty cars and replace with loaded cars.

The equipment consists of 46 storage battery tractors and approximately 1,400 trailers of various types, which include 160 three-wheel tip-up trailer trucks, these being so constructed that they trail with the four-wheel trailers, and approximately 150 two-wheel trucks, together with the necessary dollies and rollers. As far as conditions will permit, the four-wheel and three-wheel trailers are loaded inside of the car, but in some instances, owing to the condition of the load, the use of two-wheel trucks is necessary to carry the freight to be placed on the trailer trucks. As the trailers become loaded they are made up in trains, the longest haul placed next to the tractor, and returned by the shortest route by way of lift bridges to be set out on the platform opposite the proper car. Stevedores unload the trailers and then push the empties through the car back to the working platforms, A and D, where they are picked up by a tractor—one tractor being assigned to each unloading gang. A special gang is assigned to the handling of this machinery and bulky shipments and it is the duty of this gang to transfer the shipments.

Chicago and Northwestern Railway Company.—Within the past year there has been placed in operation in the Chicago area, one of the largest LCL transfer stations in the United States. It is located at an outlying yard at Proviso, Illinois, where carload freight can be received and forwarded to any one of the several lines of the owning company radiating from Chicago.

The transfer station consists of twelve longitudinal bays, each containing a pair of tracks separated by a platform which is level with the car floor. The outer pair of tracks on each side of the structure is for cars containing the freight to be transferred. These four tracks have a total capacity of 120 cars and are connected at each end to facilitate switching. The platforms next to the feeder tracks are 40 feet wide to provide ample space for the trailer trucks, and for their assembling into trains by the tractors that haul the trailers to outbound cars. The other 24 tracks under the roof hold the cars into which the outbound freight is loaded. These tracks enter the house at one end and terminate at concrete bumping posts at the other end, sufficient space being left at this end to provide a continuous trucking platform across the house. The platforms between these tracks are 22 feet wide and 1420 feet long. All platforms are of wooden construction with a sub-floor of 2-inch hemlock and wearing surface of ⅞-inch factory maple flooring.

To shorten the haul from the feeder tracks, lift bridges span the loading tracks at the center and the outer end of the platforms. They are 19 feet wide and 32 feet long and are raised by electric power to clear the tops of the cars when switching is being done. A cast-iron control box is set under the platform near each bridge and the controls are arranged so that any bridge may be raised or lowered independently. The roof is continuous over the entire area of tracks and platforms, the frame and support consisting of steel columns and steel bowstring trusses spaced 20 feet center to center at right angles to the longitudinal axis of the building. A skylight 8 feet wide with ribbed wire glass extends the length of the building along the center of each roof truss, coinciding with the center line of the platforms, with 12-inch ventilators spaced at 40-foot intervals.

Freight at this station is received from 18 freight houses in the Chicago territory, where the freight received is loaded directly into cars without sorting, except at the larger stations where sufficient freight is received to insure full cars for certain destinations. In these latter cases, cars go forward without passing through the transfer station, although the contents are billed at that point. All cars loaded from freight stations in this territory and received from connections are transferred at this station, cars being dispatched from the receiving stations three times daily. The cars to be transferred are run direct to the outside tracks and unloaded on the platform, or in trailer cars, as fast as received. When loading of a trailer is completed, a card is affixed to show the "run" and the car to which the contents go. When the trailer arrives at the car into which the freight is to be loaded, it is cut off, after which it is run into the car, unloaded and again placed on the platform to be picked up by a tractor on its return trip. Tractor trains containing as many as 35 trailers are hauled at one time, although ordinarily the maximum is from 15 to 20. There are 35 tractors in service and 3,000 trailers, all the trailers being equipped with self-couplers to expedite the assembling of trains. The maximum number of cars handled through the plant daily is 600.

This report is submitted as information and no conclusions presented. Definite rules cannot be established as to when and under what conditions separate transfer facilities should be provided. Each individual location must be considered on its merits and decision should be made only after a careful analysis of all the factors involved.

Summary

1. Car-to-car transfer is necessitated by railways receiving LCL freight in carload lots.

2. Until tonnage is excessive the transfer can usually be handled for the least cost at local freight stations.

3. Growth of local receipts and demand for speed may require separate transfer facilities for carload LCL freight not consigned to local points.

4. Separate transfer may be best if heavier loading and quicker distribution can be obtained without excess cost.

5. Costs in connection with maintenance of combined station should be compared with costs of two separately operated stations giving due consideration to cost of delay to freight, before decision is made.

6. Questionnaire developed 55 per cent of the railway mileage in the United States and Canada maintained 31 exclusively operated LCL car-to-car transfer stations.

Appendix D

(7-8) SCALES

M. J. J. Harrison, Chairman, Sub-Committee; J. E. Armstrong, Alfred Bousfield, A. W. Epright, E. M. Hastings, H. O. Hem, E. K. Lawrence, H. M. Roeser, H. R. Saunders, H. M. Starr.

WEIGHT CONTROL OF TEST WEIGHT CARS USED IN RAILWAY SERVICE

It appears that there exists no general standard of uniformity in the control of weights of test weight cars, although it is generally recognized that the use of a master scale is essential for the best results. These comments, therefore, are based on the hypothesis that a master scale is available and regularly used.

In this connection, it may be of interest to list here the various recognized master scales now in service in the United States, as follows:

Railway Owned

Owner	*Location*
Atchison, Topeka & Santa Fe Railway	Topeka, Kansas
Atlantic Coast Line	Jacksonville, Florida
Baltimore & Ohio Railroad	Martinsburg, West Virginia
Chicago, Burlington & Quincy Railroad	Havelock, Nebraska
Illinois Central Railroad	Centralia, Illinois
Missouri Pacific Railroad	Sedalia, Missouri
Norfolk & Western Railway	Roanoke, Virginia
Pennsylvania Railroad	Alliance, Ohio
Pennsylvania Railroad	Altoona, Pennsylvania
Oregon Short Line Railroad	Salt Lake City, Utah
Reading Company	Reading, Pennsylvania
Southern Railway	Charlotte, North Carolina
Southern Railway	Chattanooga, Tennessee
Southern Pacific Company	Oakland, California
Union Pacific Railroad	Denver, Colorado

Other Than Railway Owned

U. S. Bureau of Standards	Chicago, Illinois
Carnegie Steel Company	Braddock, Pennsylvania
Minnesota Railroad & Warehouse Commission	Minnesota Transfer, Minnesota
Oregon Public Service Commission	Portland, Oregon
Winslow Scale Works	Terre Haute, Indiana

Through an arrangement with the American Railway Association, the U.S. Bureau of Standards tests each of these scales at approximately annual intervals, and certifies as to the condition thereof at the time of the test. The advantage and value of this feature of the Bureau's activities is recognized by all master scale owners.

Practically all of the above master scales are available to other than the owner, usually upon payment of fees varying from $7.50 to $25.00 per car. It is therefore evident that the majority of the American railways have access to at least one master scale, and, from the information available, it is apparent that most railways avail themselves of the opportunity thus afforded.

Having access to one or more of the recognized master scales, it follows that a railway should so schedule its test weight cars that each car will be at a master scale at regular intervals, preferably not to exceed three months. At these times the car should be carefully weighed by a competent person, and its weight adjusted to the nominal value thereof. For example, a car may be found to weigh 80,005 lb., in which case five pounds should be removed and the car sent out weighing exactly 80,000 lb.

It has been found most advantageous to use cars whose nominal weights are multiples of 10,000 lb., and we therefore find 30,000, 40,000, 50,000, 60,000 and 80,000 lb. to be the most popular weights. An odd weight such, for instance, as 80,450 lb., has been found to be confusing.

The weight of the car should include the car proper and all appurtenances thereto, such as car movers, etc., carried in the car, excepting only such material as is specifically carried as supercargo. This material, consisting of small tools, overclothes, etc., should all be carried in one box which, with its contents, should be removed from the car each time the car is calibrated or used in testing.

After being calibrated, the car should be sent out on its route in charge and under the care of a scale inspector. It has been demonstrated that there is a material advantage in keeping a car consistently in care of but one man on one trip or between calibrations, and, while changes in personnel are at times unavoidable, the practice of "trading" cars or men is likely to lead to unfortunate results in so far as accuracy of the weight of the car is concerned.

The man in charge of the car should always be held personally responsible for the correctness of its weight. That this may be accomplished, it will be necessary to have no road repairs made to the car except in his presence. At these times, it will be the inspector's duty to keep a careful record of the weight of all parts removed and all parts applied to the car. When the repairs have been completed, he should determine the net change in weight and immediately make suitable adjustment by adding material or taking material out of the car, thus keeping the actual weight as nearly as possible equal to the nominal weight.

Similarly, no repacking of journal boxes, when cars are so equipped, should be permitted, except in the presence of the scale inspector. There is a strong tendency at the present time to standardize on roller bearings for test weight cars, their many advantages for this service being appreciated. Such bearings, of course, require no repacking and therefore lend themselves to better control of test car weights. Like journal bearings, however, roller bearings should receive no attention en route except in the presnce of the scale inspector.

It will be necessary to issue suitable instructions to cover the above points, and to take appropriate steps to enforce such instructions.

It is also essential that the scale inspector make frequent careful inspections of his cars to insure that no change has taken place in their weights, such as that occasioned by loss of parts en route, etc., and to take immediate steps to correct the weight should any such loss be discovered.

On return to the master scale, the car should again be carefully weighed. The weight of the car on arrival at the scale should be recorded and compared with the nominal weight, and any unusual variation should be promptly investigated. As a matter of fact, the operation of test weight cars should be such as to make unnecessary routine calibrations, since satisfactory operation of properly designed cars will bring them back to the master scale with but slight variations in weight. However, calibrations are essential, for it is only thereby that constancy of weight can be checked.

After weighing the car on its return to the master scale, any heavy repairs necessary should be made. At this time, also the car should be given a thorough cleaning, and lubricant should be added as necessary to the axle bearings. When this has been done, the car should again be weighed, and its actual weight adjusted, after which it is again ready to be started over its route.

In the light of the foregoing, the following changes in Section VI—Scale Test Cars, of the "Rules for the Location, Maintenance, Operation and Testing of Railway Track Scales," as shown in the present Manual, are tentatively suggested.

Present Form	*Proposed Form*
SECTION VI—SCALE TEST CARS	SECTION VI—TEST WEIGHT CARS
1. For general track scale testing, test cars should weigh not less than a total of thirty thousand (30,000) pounds, nor more than eighty thousand (80,000) pounds. For making graduated tests and to simplify calculations, cars weighing eighty thousand (80,000) pounds and forty thousand (40,000) pounds, respectively, are suggested. The maximum weight of 80,000 pounds is suggested principally in order to reduce the number of restricted movements due to weight limits on scales, bridges, etc.	1. (Same)
2. Scale test cars of proper design should have the following characteristics:	2. Test weight cars should have following characteristics:
(a) All metal construction.	(a) (Same)
(b) Length of wheel-base not to exceed seven (7) feet.	(b) (Same)
(c) Load distributed uniformly on wheels.	(c) (Same)
(d) No unnecessary lodges or projections likely to catch and hold dirt.	(d) (Same)
(e) No unnecessary parts.	(e) (Same)

(f) Strength and durability, so that frequent repairs will not be necessary.

(g) Surface area reduced as much as possible, to limit wind pressure.

(h) Accessibility of all parts for inspection.

(i) Roller or ball bearings reduce rolling resistance, thereby providing for ease of movement by scale inspector. They do not require sponging and repacking of journal boxes, which materially changes weight of test car between periods of calibration, and for these reasons are preferable to journal bearings.

3. Test cars may be of the self-contained type, having a body of solid castings with space provided for a small amount of test weights, or of the compartment type, having a body of structural and plate steel with space for test weights equal in weight to that of the car. The car of the self-contained type is preferable.

4. When supercargo (consisting of tools, overclothes, etc.) is carried in test car, it should be removed when the weight of car is being verified on master scale, also when testing track scales. To facilitate handling of supercargo, it should be contained in a removable steel box, properly stencilled to show that it is not a part of the test load. (See cut below.) There should be stencilled on the outside of each of the doors of the compartment in which this box is carried the following note:

> "This box contains supercargo, such as tools, etc., used for adjusting track scales, and must be taken out of car when car is weighed on master scale and when testing track scales."

5. Scale test cars should be moved on the rear end of trains, just ahead of the caboose.

6. Scale test cars should not be kept on trains in yards while the

(f) (Same)

(g) (Same)

(h) (Same)

(i) Roller or ball bearings of proper design, preferably the former.

3. Test weight cars should preferably be of the self-contained type with solid body in which a small space is provided for a limited number of test weights. When it is impracticable to provide a self-contained car, a compartment car, with body of structural and plate steel, at least one-half of the weight of which consists of test weights carried in the compartments, may be found to be serviceable.

(See paragraph 9 below.)

4. Test weight cars should be handled on the rear end of trains, just ahead of the caboose.

5. Test weight cars should not be kept in trains in yards during

latter are being switched, but should be so placed that rough handling will be avoided. In no case should these cars be subjected to impact at a speed greater than two (2) miles per hour.

7. All excess weight, resulting from the accumulations of snow and ice, should be removed from scale test cars before they are placed on scales for the purpose of testing. To remove this, an engine with steam hose connections may be used to thaw it, or hydro-carbon, where available may be employed if used with care.

8. Oiling and repacking of test cars should be looked after while test car is at master scale for verification.

9. Scale test cars should be verified on master scale at least every three (3) months, or after each general test trip.

10. In order to maintain the verified weight of the scale test car at all times, no repairs of any nature should be made while in transit or boxes sponged without notifying the scale inspector in charge of the car, in order that he may be present to determine and arrange to take care of any differences between the weight of parts applied and those removed. To insure compliance with this rule, there should be located in a conspicuous place, so that it can be read from either side of the car, a badge plate with some such notice as:

"Do not oil or repack boxes or make repairs to this car unless directed by scale inspector."

switching, but should be so placed that rough handling will be avoided. In no case should these cars be subjected to impact at a speed greater than two miles per hour.

6. All excess weight, resulting from accumulations of snow or ice, should be removed from test weight cars before they are placed on scales for the purpose of testing or on a master scale for calibration. The use of steam is recommended for this purpose.

(See paragraph 11 below.)

7. Test weight cars should be calibrated on a certified master scale before being started on each general test trip, and not less frequently than once every three months. At the time of calibration, the actual weight of the car should be made equal to its nominal weight, which should be a multiple of 10,000 pounds.

8. Each test weight car should be in the care of but one scale inspector between calibrations, and he should be held personally responsible for the maintenance of the correct weight of each car in his care. To this end, the following rules should be enforced:

(a) No repairs to any test weight car may be made except in the presence of the scale inspector in charge thereof.

(b) Journals of test weight cars may not be repacked unless directed by the scale inspector in charge thereof.

(c) Each test weight car should carry a conspicuous badge plate, visible from either side of the car, and carrying a notice to the following effect:

"Do not oil or repack boxes or make repairs to this car unless directed by scale inspector."

(d) Should any change be made in the weight of a test

11. In case a scale test car is damaged so as to require extensive or heavy repairs, it should be returned to the master scale for verification after the repairs have been completed.

weight car, it is the duty of the scale inspector to determine the amount of such change and immediately to make suitable correction. If the change in weight cannot be determined satisfactorily, the car should be returned to the master scale for calibration before again being used.

9. The nominal weight of each test weight car should include the car proper and everything contained therein, excepting only such material as is specifically carried as supercargo. This material, consisting of tools, overclothes, etc., when carried, should be contained in a removable steel box, the outside of which should be stencilled to show that it is not a part of the test load. This box and its contents must be removed from the car when being calibrated and when used for testing track scales.

10. When a test weight car is returned to the master scale for any reason, the actual weight of the car upon its arrival should be determined and recorded. Any unusual variation between that weight and the nominal weight of the car should be promptly and fully investigated.

11. After the weight of the car on its arrival at the master scale has been determined, the car should receive any heavy repairs which are needed or may be needed before the next trip to the master scale, and should be thoroughly cleaned. At this time the axle bearings should receive any necessary lubrication and packing, after this has been done the car should be calibrated as outlined in paragraph 7 hereof.

Conclusion

1. It is recommended that the phraseology on the right-hand side of the foregoing be submitted for the version now in the Manual.

REPORT OF COMMITTEE XVIII—ELECTRICITY

AND OF THE

ELECTRICAL SECTION, AMERICAN RAILWAY ASSOCIATION

SIDNEY WITHINGTON, *Chairman;*
J. V. B. DUER, *Vice-Chairman;*
F. AURYANSEN,
B. F. BARDO,
H. M. BASSETT,
R. BEEUWKES,
L. S. BILLAU,
D. J. BRUMLEY,
H. C. CROSS,
H. A. CURRIE,
J. C. DAVIDSON,
J. H. DAVIS,
C. L. DOUB,
J. S. HAGAN,
F. D. HALL,
P. LEBENBAUM,
W. P. MONROE,
W. L. MORSE,
R. J. NEEDHAM,
A. E. OWEN,
J. A. PEABODY,
H. W. PINKERTON,
J. T. SEAVER,
J. H. VAN BUSKIRK,
W. M. VANDERSLUIS,
H. M. WARREN,
L. S. WELLS,
L. C. WINSHIP,
C. G. WINSLOW,
R. P. WINTON,
G. I. WRIGHT,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of the Manual (Appendix A).

(2) Study of the subject of inductive co-ordination of traction and communication circuits (Appendix B).

(3) Further study of the water power developments on Passamaquoddy Bay and on the St. Lawrence River, and on the Alabama power development on the Tennessee River; together with development of information regarding the extent of use of water power for railroad operation at the present time (Appendix C).

(4) Collaboration with American Committee on Electrolysis and general study of the subject of electrolysis (Appendix D).

(5) Co-operation with the United States Bureau of Standards in connection with revision of the National Electrical Safety Code, and negotiations with the National Electric Light Association in connection with wire crossing specifications (Appendix E).

(6) Revision of Transmission Line and Catenary Specifications (Appendix F).

(7) Study of economics of railway location as affected by electrical operation, collaborating with Committee XVI—Economics of Railway Location (Appendix G).

(8) Study of insulating tapes, with especial reference to cambric and paper tapes (Appendix H).

Bulletin 312, December, 1928.

(9) Continuation of the study of insulators, and investigation of insulators made of boro-silicate glass (Appendix I).

(10) Review of the subject of clearances of overhead conductors (Appendix J).

(11) Continuation of study of protection of oil sidings from danger due to stray currents (Appendix K).

(12) Continuation of the study of track and third rail bonds, with especial reference to: (a) Study of details of bond design with a view to developing specifications covering the different classes of bonds; (b) Collection of information as to methods and extent of practice in reapplying bonds; (c) Collection of data on compositions used, if any, on rail joints to replace bonds; (d) Study of contact areas and resistances for different types of bonds; (e) Compilation of information concerning rail joint clearance and its effect on rail bond design (Appendix L).

(13) Revision of incandescent lamp schedule and continuation of study of flood lighting for classification yards and other railroad purposes (Appendix M).

(14) Continuation of studies in connection with design of indoor and outdoor substations (Appendix N).

(15) Investigation of cables for carrying high voltages (Appendix O).

(16) Study of the application of corrosion-resisting materials to railroad electrical construction (Appendix P).

Action Recommended

(1) That the revised Incandescent Lamp Schedule be placed in the Manual in accordance with recommendation of Sub-Committee No. 13, Appendix M, to take the place of the 1926 Schedule which was removed from the Manual by action at the Annual Meeting in 1928.

(2) That the report on Inductive Co-ordination contained in Appendix B be accepted as an indication of progress and the subject continued.

(3) That the report on Water Power contained in Appendix C be accepted as information and the subject continued.

(4) That the report on Electrolysis contained in Appendix D be accepted as an indication of progress, and the subject continued, with representation on the American Committee on Electrolysis without commitment as to subscription or dues.

(5) That the report on Co-operation with the United States Bureau of Standards and Negotiations with the National Electric Light Association contained in Appendix E be accepted as information and the subject continued.

(6) That the report on Overhead Transmission Line and Catenary Construction contained in Appendix F be accepted as information and the subject continued.

(7) That the report on Collaboration with Committee XVI—Economics of Railway Location, contained in Appendix G, be accepted as information and the subject continued.

(8) That the report on Standardization of Insulating Tapes contained in Appendix H be accepted as information and the subject continued.

(9) That the report on Standardization of Insulators contained in Appendix I be accepted as information and the subject continued.

(10) That the report on Clearances of Overhead Conductors contained in Appendix J be accepted as information and the subject continued.

(11) That the report on Protection of Oil Side Tracks from Danger due to Stray Currents contained in Appendix K be accepted as information and the subject continued.

(12) That the report on Track and Third Rail Bonds continued in Appendix L be accepted as an indication of progress and the subject continued.

(13) That the report on Illumination contained in Appendix H be accepted as an indication of progress and the subject continued; that the revised Incandescent Lamp Schedule presented with this report be placed in the Manual.

(14) That the report on Design of Indoor and Outdoor Substations contained in Appendix N be accepted as an indication of progress and the subject continued.

(15) That the report on High Tension Cables contained in Appendix O be accepted as information and the subject continued.

(16) That the report on Application of Corrosion-Resisting Materials to Railroad Electrical Construction contained in Appendix P be accepted as an indication of progress and the subject continued.

Recommendations for Future Work

(1) Revision of the Manual as may be found desirable.

(2) Continue study of the subject of Inductive Co-ordination, as well as representation on the American Committee on Inductive Co-ordination or other similar Joint Committees as may be desirable.

(3) Continue the study and report further on water power developments on Passamaquoddy Bay, the St. Lawrence River, and the Tennessee River, when and if additional data become available; also study and report on any other water power development projects which the Sub-Committee may deem appropriate, as well as collect and submit any additional information which may become available with regard to the application of water power to railroad electric operation.

(4) Continue the study of Electrolysis Co-ordination and representation on the American Committee on Electrolysis without commitment as to subscription or dues.

(5) Continue collaboration with the Engineering Standards Committee and the United States Bureau of Standards in the revision of the National Electrical Safety Code and other Codes of similar character; continue negotiations with the National Electric Light Association and study of Electric Light, Power Supply, and Trolley Lines Crossing Railroads, co-operating with other Sections of the American Railway Association as may be deemed necessary. Continue State representatives and their alternates.

(6) Revise and keep up to date the Transmission Line and Catenary Specifications with view to ultimately including in the Manual.

(7) Continue the study of Economics of Railway Location as affected by electric operation, collaborating with Committee XVI, Economics of Railway Location.

(8) Continue the study of insulating tapes.

(9) Continue the study of insulators, with a view of keeping up to date the specifications previously adopted.

(10) Collect data on clearances for Third Rail and Overhead Construction from the various railroads now electrified and report same as of November 1, 1929. Review the subject of clearances with the three other Committees of the American Railway Engineering Association, namely, Iron and Steel Structures; Roadway, and Signal Section Committees, and with the Special Committee on Clearances, and such other bodies as may be desirable in an endeavor to reconcile the conflicts between the various clearance diagrams now published in the Manual.

(11) Continue the study of protection of oil side tracks from danger due to stray currents with a view to keeping up to date rules previously adopted, and including static electricity if it is found desirable.

(12) Continue the study of track and third rail bonds, co-operating with other technical organizations interested, with especial reference to:

(a) Study of details of bond design with a view to developing specifications covering the different classes of bonds.

(b) Collection of data on compositions used on rails and rail joints to replace bonds.

(c) Study of contact areas and resistances for different types of bonds.

(13) Keep up to date the Incandescent Lamp Schedule; develop specifications for Incandescent Lamps; continue the study of flood lighting for classification yards and for other railroad purposes.

(14) Continue the study of design of Indoor and Outdoor Substations.

(15) Continue investigation of cables for carrying high voltages.

(16) Continue study of the Application of Corrosion-Resisting Materials to Railroad Electrical Construction, making arrangements if possible for comprehensive tests of materials suitable for use in electrical construction.

In order to avoid duplication of effort, especially in such forms of activity as collecting technical data, etc., it is planned to co-operate with other technical organizations, with a view to compiling joint reports so far as possible. Such co-operation should increase the efficiency of Committee work to a notable degree.

During the past year there has been an irreparable loss to the Committee on Electricity and to the Electrical Section in the death of Edwin Britton Katte, to whose inspiration and enthusiasm we all owe more than can be expressed. A resolution prepared by a Special Committee appointed for the purpose is presented below.

Respectfully submitted,

Committee on Electricity,

Sidney Withington, *Chairman.*

Resolution

The Electrical Section of the American Railway Association records with sorrow the death, on July 19, 1928, of Edwin Britton Katte, Chief Engineer Electric Traction, New York Central Lines, and Chairman of the Electrical Section.

Mr. Katte was an active member of a number of technical societies and served with conspicuous ability as a Director of the American Railway Engineering Association for three years, as Chairman of its Committee on Electricity for eleven years, and as Chairman of the Electrical Section since its reorganization two years ago. Under his leadership the scope of activities of the Section has been materially broadened and the usefulness of its reports to railroads enhanced. His broad electrical experience and distinguished technical attainments, sound common sense, high integrity and lovable character not only made him a most capable leader and advisor in the activities of the Electrical Section, but endeared him to all of his associates.

We extend our profound sympathy to his bereaved widow and members of his family, and direct that a copy of this resolution be conveyed to them; also to the American Railway Engineering Association and the American Railway Association.

J. H. Davis, Chairman;
J. T. Seaver,
Sidney Withington,
G. I. Wright.

Committee.

Appendix A

(1) REVISION OF MANUAL

W. M. Vandersluis, Chairman, Sub-Committee; A. E. Owen, Vice-Chairman, Sub-Committee; J. H. Davis, W. L. Morse.

Conclusions

1. Place in the Manual the revised Incandescent Lamp Schedule as per recommendation of Sub-Committee No. 13, Appendix M, to take the place of the 1926 Schedule, removed from the Manual by action at the Annual Meeting in 1928.

Appendix B

(2) INDUCTIVE CO-ORDINATION

Sidney Withington, Chairman, Sub-Committee; R. Beeuwkes, J. C. Davidson, J. V. B. Duer, W. M. Vandersluis.

The American Railway Association continues representation on the American Committee on Inductive Co-ordination through representatives of Telegraph and Telephone, Signal, and Electrical Sections, the representatives being as follows: L. Behner, W. A. Jackson, W. F. Follett (G. H. Dryden, alternate), J. V. B. Duer, and Sidney Withington. The American Committee on Inductive Co-ordination has been inactive this year, but it has been tentatively proposed to inaugurate discussions on inductive co-ordination between the representatives of the American Railway Association and the National Electric Light Association, and also with the American Telephone and Telegraph Company, which it is intended will to some extent cover the scope of that Committee.

In view of recent developments in the field of inductive co-ordination, it was the opinion of the Electrical Section that the sub-committee should include among its activities this year a brief statement of the fundamental principles of inductive co-ordination. It was also considered desirable to present a description of problems met and solved in the Illinois Central electrification—the first important example of 1500 volt direct current electrification applied to heavy trunk line suburban service. These problems cover not only inductive co-ordination but electrolytic co-ordination. The portion of the report dealing with electrolysis will be found in the report of Sub-Committee No. 4, Appendix D.

GENERAL PRINCIPLES OF INDUCTIVE CO-ORDINATION

When power circuits, either A.C. or D.C., are operated in proximity to communication lines, voltage may be induced in the neighboring communication circuits. This subject has been discussed in previous reports of the Committee on Electricity, and reference is made especially to the reports of Proceedings for 1919 (page 203), 1920 (page 272), 1921 (page 128), and

1922 (page 88). The previous discussions referred to have largely dwelt in a general way upon the means employed in individual instances to co-ordinate the power and communication facilities to minimize or eliminate interference. In the present report your committee endeavors very briefly to bring these data up to date and to supplement the discussions with a brief general exposition of the salient features of the somewhat complicated problems involved. Reference is also made to reports of Committee No. 7, American Railway Association, T. & T. Section.

The problems met with in traction circuits are in many respects similar to those involved in co-ordinating other types of power circuits with communication facilities, but on account of the use of the ground as a return there are some problems encountered in traction circuits which are not encountered with balanced three-phase circuits even where the neutral may be grounded. In this latter instance a ground in any one leg of the three-phase circuit is somewhat analogous to a ground in a traction circuit with the exception that in some cases the neutral of the power circuit may be grounded through relatively high resistance which limits the short circuit current. In the case of power systems operated with a grounded neutral, major inductive troubles usually occur only in the event of a fault whether the neutral connection to ground is of high or low resistance. Some disturbances may result, however, from extremely unbalanced loads, especially if the ground connection resistance is low. With traction circuits it may be necessary to consider ground currents not only in the event of a fault, but also with heavy loads.

The voltage which may be induced in the communication circuits adjacent to a ground return traction circuit is from two causes: First, electro-static, or *"electric"*; second, electro-magnetic, or *"magnetic."*

For any given relative position of the trolley conductor and communication circuit the electrically induced voltage is proportional to the *potential* of the trolley circuit, while magnetically induced voltage is approximately proportional to the *current* in the trolley circuit. For alternating current of any given frequency, the voltage induced magnetically is proportional to the magnitude of the current, and for a given magnitude of current is nearly proportional to the frequency. Some of the effects of electric induction, such as noise, depend on the time rate of change of the voltage. Thus the shape of the power wave and odd harmonics super-imposed on the power wave are of importance.

In so far as electric induction is concerned, a trolley wire may be looked upon as a conductor at a potential above that of the ground, with electrostatic capacity. This conductor also has capacity as compared to telegraph or telephone circuits, which in turn possess capacity to ground. If the communication wires were perfectly insulated from the ground, the induced potential would rise to a value determined by the relative capacity of the wires to the trolley wire and to earth. If, on the other hand, the communication circuits are connected to ground by means of drainage coils, which is often the case where exposure exists, they act as one plate of a condenser, the trolley system acting as the other plate. Charging current thus flows between the ground and the communication circuits proportionate in magnitude to the relative capacities between them and the trolley wire. Because of capacity or leakance to ground outside of exposures, longitudinal currents may be set up by electro-static induction. These currents would be proportional to the admittance between the communication circuits and the trolley wire, provided as is frequently true, that this admittance is large compared to the admittance of the communication conductors to ground.

The electric induction problem is not usually serious, for the charging current is generally divided among a considerable number of communication wires and the amount in each is therefore usually negligible. Furthermore, if there were but one communication wire which was entirely insulated from the ground, its capacity to earth would be so much greater than its capacity to the trolley wire that extremely high voltage would not be experienced. For close exposure of open wire circuits, noise due to electric induction may be important. At low frequencies and under normal operating conditions, electric induction is undoubtedly of minor importance compared to magnetic induction, as regards effects upon the functioning of communication equipment. This does not mean, however, that electric induction need not be taken into account in considering, for example, hazards to linemen working on closely exposed open wire lines, such as the communication circuits of railway companies with high voltage trolleys. Electric induction in such cases might require such measures as grounding the wires when they are being worked upon. A grounded lead sheath cable entirely prevents the accumulation of a static charge on the conductors.

In considering magnetic induction, the trolley wire and its return in the rail and ground acts as the primary winding of a large air core transformer, the paralleling communication wires being the secondary. The induced voltage in a wire paralleling the trolley circuits varies as the logarithm of the ratio of the distance between the paralleling wire and the two sides of the power circuit (trolley and ground), and of course to the length of exposure.

The induced voltage in a metallic telephone circuit is of two sorts; first, the voltage in the pair as a unit, which appears as electro-motive force along the wires; second, that appearing as an electro-motive force *between* the two wires of the circuit, that is, the difference between the voltages induced in the two wires. In the first instance there is no tendency for current to flow from one wire to the other, even though both may be of relatively high potential above ground. In the second instance, on the other hand, a current flows from one wire to the other through the communication apparatus, with possible resultant noise.

The distribution of potential due to electric induction of a trolley circuit on an insulated telephone circuit depends upon the relative impedences of the various sections of the line to ground, that is, the voltage to ground is determined largely by the capacity of the wires to ground at the various points. In case the current through the inducing circuit is constant throughout the exposure and the separation is uniform and the telephone circuit is uniform within the exposure and has symmetrical extensions on either side of the exposure, the distribution of potential would be such that the mid-point of the telephone line would be at ground potential with each end at half the theoretical value of the induced voltage to ground, one end being positive and the other end being negative with respect to ground.

If the wire is grounded at both ends a current will flow in it which is proportional to the voltage and inversely proportional to the impedence of the circuit. It is difficult to distinguish between the current thus induced and a ground return current flowing parallel to the power return on account of high ground potential. This complicates somewhat the analysis of induced voltage.

The voltages induced in the two wires of a communication circuit will in general be unequal in magnitude and slightly different in phase relation. The inductive effects may conveniently be analyzed by dividing the induced voltages into two classes, namely, longitudinal and transverse. Longitudinal voltage is of identical value in both sides of the circuit and tends to cause current to flow to earth through both wires in parallel. Transverse voltage is of equal magnitude but of opposite polarity in the two wires and tends to circulate current through the metallic circuit. Longitudinal induction is a function of the current and frequency of the power circuit and of the ratio of the separations between the communication conductor and the two sides of the power circuit. Transverse induction is a function of the same values and also of the degree of separation between the two wires of the communication circuit. Transverse induction values can be obtained by calculating the longitudinal induction for each communication wire separately and then determining the difference between the values thus obtained.

In general, transverse voltage will be small in comparison with longitudinal voltage and may be displaced in phase as compared with it. The division of the induced voltage into the two classes makes it possible to state clearly the effects of transpositions. Transverse induction may be reduced to a very small magnitude by transposition of the wires at poles in the usual manner or by the use of twisted pairs of conductors, or by cables. Longitudinal induction in the communication circuit as a whole cannot be reduced by transposition of the communication circuit itself. Longitudinal induction may be reduced in the case of balanced currents in all-metallic power circuits by transposing the power circuit conductors. It is obvious, however, that a grounded power circuit, as, for example, a trolley—rail circuit, cannot be transposed.

The magnitude of voltage induced by trolley circuits with track and ground return may be relatively large compared with that of a balanced three-phase metallic circuit, because of the relatively large distance between the trolley and the return through the rail or earth. If the return were entirely in the rail, it is obvious that it would be relatively easy to so locate the communication circuits that they would be at the same distance from the trolley and the rail, but it is usually not possible to attain this ideal, since the effective average location of the ground return for 25 cycle currents may be from a few hundred feet to a few thousand feet below the surface of the ground. The equivalent depth of the earth current tends to decrease with increasing frequencies.

The situation may be expressed mathematically by the following expressions:

V = voltage induced per mile of parallelism.
I_t = current in trolley.
I_g = current in ground.
I_e = current in rails.
D = distance trolley to communication line—feet.
D' = distance rail to communication line—feet.
D'' = distance equivalent path of earth current to communication circuit—feet. (Varies with earth conditions; must be determined in individual cases.)
C = constant—.1164 for 25 cycle trolley circuits and logarithms to base 10.
l = length of parallelism, miles.
$\omega = 2\pi \times$ frequency (cycles per second).

$$\text{Mutual Inductance} = 2l\left(\log_e \frac{2l}{D} - 1\right)10^{-4}\ \textit{henrys.}$$

$$V = \omega \times \text{Mutual Inductance.}$$

To translate these formulæ to easily used quantities is relatively simple, and a general formula applicable for induced voltage is (logarithms are to base 10):

$$V = CI_g \log \frac{D''}{D} + CI_e \log \frac{D'}{D}, \text{ which may be written:}$$

$$V = CI_t \log \frac{D''}{D} + CI_e \log \frac{D'}{D''}$$

This in turn may be modified readily to read:

$$V = I_t\left(C \log \frac{D''}{D} + KC \log \frac{D'}{D''}\right), \text{ where } K \text{ is the ratio } \frac{I_e}{I_t}$$

The term included in the brackets may be called the *"coefficient of induction."*

When the induced voltage is known for each section of the exposure, the total voltage induced on a parallel communication circuit may obviously be readily computed by the vector summation of the voltages induced in the various individual sections.

In planning an electrification system, co-ordination should be considered from the start, for by estimating in advance the probable induced voltages in exposed communication circuits, the layout of substations and the general arrangement of the railway system can often be advantageously designed from the standpoint of avoiding special devices which are expensive and may be undesirable in reducing flexibility of power supply and reliability of operation.

If the system is designed on the basis of short circuits assumed at various locations, and co-ordination adapted accordingly, it is usually entirely satisfactory for normal operation, although with the use of high speed circuit breakers to quickly clear the line in the event of trouble, it may happen that normal load conditions are controlling.

The various methods described applied to co-ordinate the power and communication facilities with a view to reducing the induced voltage may be divided into three classifications applying to (a) power systems, (b) inductive coupling between systems, and (c) communication systems. The application is described in some detail in previous reports referred to above.

(a) Various measures are applied to *power supply systems.* Short circuit currents are limited by the use of high reactance step-up transformers and low reactance step-down transformers, and by reactance coils in case of relatively unimportant branches supplied from main line electrifications. The "through-feed" current may be reduced by proper proportioning of reactance in distribution circuits. Keeping return current out of the ground and as close to the trolley as possible reduces the mutual inductances and the return current is thus confined to the rail so far as practical by effective rail bonding and other devices. Since magnetic induction is a function of current, the advantages of high supply voltage and consequently low current, are obvious, although this may result in large short circuit currents in the event of a fault. Limiting the duration of disturbances by use of high speed circuit breakers is advantageous in reducing total energy transferred to the communication system. Harmonics and commutation ripples should be limited as much as practicable by proper design of generating and transforming equipment, or by additional apparatus.

(b) *Inductive coupling* between power supply and communication circuits may be reduced by increasing the separation between power supply and communication circuits and by reducing the effective length of the exposure.

(c) The measures adopted in the *communication systems* are usually for the purpose of draining the induced voltage to the ground so it will not reach troublesome proportions. In some instances the voltage of the line wires in communication circuits is allowed to reach any magnitude which may be induced by the neighboring traction circuit, the instruments at each station being protected by 1:1 transformers insulated for the maximum line voltage. It is also desirable to keep the voltage in each element of a circuit as closely similar to that in the others as possible by carefully balancing the two sides of the circuit. There is also applied protection to prevent voltage from rising to so high a value as to endanger insulation or apparatus, by automatically grounding the circuits if necessary. All metallic circuits are obviously advantageous as compared to grounded circuits. Lead covered cables are desirable where they can be economically justified.

The chief difficulties experienced in communication circuits may be classified as follows:

Noise, on account of induced voltages of audible frequency due to harmonics or commutation ripples.

False ringing on telephone circuits and "chatter" on telegraph and printing telegraph circuits.

Fire hazard, electric shock, or interruption of service due to high voltage in communication apparatus.

Acoustic shock due to sudden heavy flow of current and unbalanced 'phone circuits.

The important single phase railroad installations placed in operation since the previous descriptions make use of essentially the same devices as previously applied, with such modifications as local conditions made desirable.

On the Virginian Railway, where the magnitude of concentrated power demands exceeds that developed for perhaps any other railroad in the world, there was installed single phase metallic transmission at 88 KV, stepping down at relatively frequent substations to trolley voltage. In addition to thus providing frequent feed points, balancing transformers with balance feed wires were installed, somewhat similar to the three wire system originally installed on the New York, New Haven & Hartford Railroad, except that on account of the fact that provision was made for ultimately raising the trolley voltage to 22 KV, and in order to reduce "through-feed" current magnitudes, the balance circuit is 22 KV.

On the Pennsylvania Railroad Philadelphia-Wilmington electrification, frequent transpositions of 132 KV transmission lines have been made. Both the high voltage and the transpositions aid in induction interference correction. This high voltage is stepped down to a trolley voltage of 12 KV at relatively frequent substations. Trolley feeder and catenary faults are quickly cleared from the system by means of high speed circuits breakers which operate in approximately .04 second.

The Danbury Branch of the New York, New Haven & Hartford Railroad between South Norfolk and Danbury, Conn., a single track line about 25 miles long, which was electrified in 1925, employs balancing transformers at three locations and a balancing feeder similar to those employed on the main line electrification. A three ohm reactor in series with the trolley and feeders at South Norwalk limits short circuits, and high speed circuit breakers clear the line in the event of abnormal conditions.

The Bay Ridge, N. Y., electrification of the New York Connecting Railroad and Long Island Railroad, completed in 1927, is virtually an extension of the New Haven electrification. Balancing transformers similar to those employed on the older electrification, together with associated balancing feeders, but of 3000 KVA capacity, are installed at five locations.

The two-track New York, Westchester & Boston Railway extension between Larchmont Junction, N. Y., and Rye, N. Y., has been installed parallel to the New Haven electrification. This is a stub-end feed from Columbus Avenue, N. Y., about eight miles. The Westchester tracks are cross bonded at frequent intervals to the parallel New Haven system, the rails of which provide a low resistance return path to the source of power at West Farms, New York.

The Illinois Central suburban electrification at Chicago was completed in 1926 and is of interest in that it is the first instance where mercury arc rectifiers were employed in trunk line electrification in this country.

When electric operation was started, a considerable portion of the communication circuits along the right-of-way were open wire. The high frequency harmonic ripples from the mercury arc rectifiers caused considerable electro-static induction in the wires and consequently interfered to some extent with telephonic communication. These wires have now been cabled and the most of the noise trouble cleared up, although there is still some interference.

The power company is experimenting with filters on the load side of the rectifiers, designed to eliminate the more objectionable frequencies from the rectifier voltage ripple, and it is believed, based on experience elsewhere, that they will eliminate all troubles from inductive interference.

Conclusions

It is recommended that this report be accepted as information and the subject continued.

Appendix C

(3) WATER POWER

R. J. Needham, Chairman, Sub-Committee; R. Beeuwkes, Vice-Chairman, Sub-Committee; H. M. Bassett, J. C. Davidson, H. Flood, Jr., H. C. Griffith, F. D. Hall, W. L. Morse, R. P. Winton.

The activities of the Sub-Committee on Water Power have been outlined for the present year as follows:

1. Continue study of Tidal Water Development on Passamoquoddy Bay and St. Lawrence River when actual construction is in progress.
2. Report on Alabama Power Development on Tennessee River.
3. Present information as to extent that water power is used for railroad operation at the present time.

ST. LAWRENCE RIVER AND PASSAMOQUODDY BAY

No actual construction work has been started on either the St. Lawrence River or the Passamoquoddy Bay projects.

ALABAMA POWER DEVELOPMENT

It was not considered desirable for the Sub-Committee to visit the water power developments of the Tennessee River until such time as the political situation relating to them has been cleared up, and the developments are undertaken. The one important development on this river is the Muscle Shoals, and the status of this project is so involved in Federal politics that very little can at this time be said beyond what was contained in last year's report.

The Muscle Shoals development was authorized under the National Defence Act of June, 1916, in order to produce nitrate required for munitions of war, as well as being useful for making fertilizer. The Act also provided that the plant should be constructed and operated solely by the Government. This great power plant, and the two nitrate plants, which were completed and ready for operation after the close of the Great War, have been operated only spasmodically and have never yet served the purpose of their creation. Although numerous solutions have been presented before Congress, no definite action has yet been taken to place the plant in operation and begin to return to the people some of the treasure that has been lavished upon this enterprise.

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The Sub-Committee feels it might be well at this time to outline the Water Power policy of the United States, as it is embodied in the Federal Water Power Act of June 10, 1920.

Water power development on navigable streams was left to the several States until 1899 when all structures to be constructed in or over them were placed under control of the Federal Government, following which any water power development on a navigable stream was required to have authority from Congress or an appropriate State Legislature and the plans therefor approved by the Secretary of War.

Since then, Congress has during many years considered the subject of how best to utilize the vast water power of the country but not until 1920 did the United States definitely commit itself to a water power policy when it passed an act to provide for the improvement of navigation, the development of water power and the use of public lands in relation thereto, a synopsis of which follows:

THE FEDERAL WATER POWER ACT

This act, approved June 10, 1920, created a Federal Power Commission composed of the Secretary of War, the Secretary of the Interior and the Secretary of Agriculture whose work shall be performed by and through the Engineering, Technical and Clerical personnel of their respective Departments.

The Commission is empowered in co-operation, where practicable, with the Executive departments and other agencies of State or National Governments to investigate and collect data concerning the utilization of water resources of any region, the water power industry and its relation to other industries and to interstate or foreign commerce, and concerning the location, capacity, development costs and relation to markets of power sites; and to make public the information secured.

To issue licenses to United States citizens, or to any association of such citizens, or to any corporation organized under the Laws of the United States or any State thereof, or to any State, or Municipality for the purpose of constructing, operating and maintaining dams and power plant facilities necessary or convenient for the development and improvement of navigation and for the development, transmission and utilization of power from any of the navigable waters or upon any part of the public lands and reservations of the United States.

To issue preliminary permits, maintaining priority of application, for the purpose of enabling applicants for a license to secure data and submit plans, specifications and estimates of costs as required for a full understanding of the proposed project.

To prescribe rules and regulations for the establishment of a system of accounts; to hold hearings and to order testimony in connection with a license, or regulations of rates, service or securities and to perform all acts necessary and proper to carry out the provisions of the Act.

Licenses are issued for a period not exceeding fifty years, conditioned upon compliance with State Laws and acceptance of terms and conditions prescribed by the Commission and revocable only by Court procedure for violation of terms. They may be altered or surrendered only upon mutual agreement with the Commission.

In issuing preliminary permits or licenses and in issuing licenses to new licensees at the expiration of an original license, preference is to be given to States and Municipalities provided the plans for the same are deemed equally well adapted; otherwise the Commission may give preference to the applicant the plans of which it finds to be most suitable. The project adopted, including maps, plans and specifications, shall be such as will be best adapted to a comprehensive scheme of improvement and utilization for the purposes of navigation, water power development, and of other beneficial public uses of the region.

During the license period the licensee must pay to the United States reasonable annual charges for the purpose of re-imbursing it for the cost of the administration of the Act; for recompensing it for the use, occupancy and enjoyment of its lands or other property and for the expropriation of excessive profits until the respective States shall make provision for preventing excessive profits, or for the expropriation thereof to themselves, or until the amortization is reached and in fixing such charges the Commission shall seek to avoid increasing the price to consumer of power.

After the first twenty years of operation out of surplus earnings, if any, the licensee must maintain amortization reserves to be held until the termination of the license, or to be applied from time to time in reduction of the net investment.

Whenever a licensee is directly benefited by the construction work of another licensee of a storage reservoir or headwater improvement, the licensee so benefited must reimburse the owner of such reservoir for such part of the annual charges as the Commission may deem equitable.

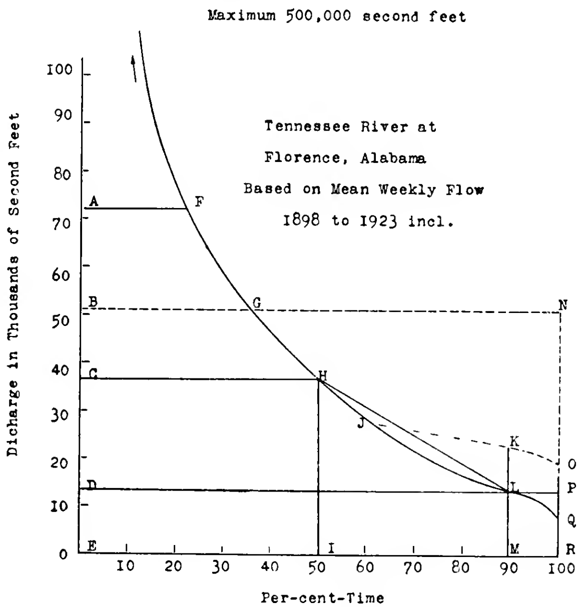
Combinations, agreements, arrangements or understandings, expressed or implied, to limit the output of electrical energy, to restrain trade or to fix, maintain or increase prices for electrical energy or service are prohibited.

If the dam or other project works are constructed in any of the navigable waters of the United States, the Commission may, in order to improve navigation facilities, require the licensee to construct, without expense to the United States, locks, booms or sluices; or dedicate lands to the United States with right of passage through its dams or structures in case the United States should construct such facilities. In either case the licensee must furnish the power for operating the facilities without cost to the United States.

Upon two years' notice in writing from the Commission the United States is to have the right upon the expiration of any license to take over, maintain and operate any project of the licensee upon paying the net investment in the project not to exceed the fair value thereof as determined by agreement or by arbitration.

Upon the expiration of the original license the Commission may issue a new license to the original licensee upon terms and conditions authorized or carried under the then existing laws or issue a new license under such laws to a new licensee upon payment of such amount and under such contracts as would be required of the United States. Otherwise, the United States may issue from year to year an annual license to the then licensee under terms and conditions of the original license until the property is taken over.

When, in the opinion of the President of the United States, evidenced by a written order addressed to the holder of any license, the safety of the United States demands it, the United States shall have the right to enter upon and take possession of any project constructed under a license for the purpose of manufacturing explosives, nitrates or munitions of war or for any purposes involving the safety of the United States.



All licenses require that the licensee shall abide by reasonable regulation of the services to be rendered to consumers of power, and of rates and charges of payment therefor as may be prescribed by any duly constituted agency of the State in which the service is rendered. Whenever any of the power enters into interstate or foreign commerce, the rates charged therefor shall be reasonable, non-discriminatory and just to the customer.

The right of eminent domain, if required, is conferred upon the licensee.

This act affects more than 80 per cent of all the water power available. It is enabling, in that it calls upon the Commission to establish sites and develop data for dams consistent with the beneficial uses of a comprehensive scheme, advantage of which may be taken by anyone intending to utilize the water of any navigable stream or waters located on public lands. Already licenses have been issued that cover the completion of more than 3,000,000 horsepower in the next few years.

It is estimated that 12,000,000 horsepower has been developed out of possibly 60,000,000 horsepower that may be obtained from the rivers and streams of this country. Of that now available the great majority lies in the Northwest and Southwest, with lesser amounts in the Rocky Mountain region and in the central and northern Appalachians.

Since the power resources in the Northwest and the Southwest are generally too remote for economical transmission of power to densely populated areas, their logical use would seem to be for electrification of railroads that must otherwise haul coal long distances or rely upon oil for fuel.

ELECTRIFIED STEAM RAILROADS—1927

Statement of electrified steam railroads, 1924, which was submitted with our report in 1925 covering electrification data, and the extent which water power is used in electrified steam railroads, has been brought up to date, that is, up through the year 1927, in accordance with statement which accompanies this report.

The Sectional Committee of the American Engineering Standards Committee on the Rating of Rivers, on which the Electrical Section of the American Railway Association is represented, has developed a set of Definitions and Tentative Rules for the rating of the flow of rivers, which was completed too late for appearance in last year's proceedings. Copy of the Definitions and Tentative Rule accompany this report.

SECTIONAL COMMITTEE ON RATING RIVERS

American Engineering Standards Committee Tentative Rule

Undeveloped Sites or Stretches of River

The rating of undeveloped sites will show theoretical kilowatts based on 100 per cent efficiency and gross head feasible of development for the following four conditions:

(1) Power based on flow available 90 per cent of time, i. e., the flow will be below this rate for 10 per cent of the time.

(2) Power based on flow available 50 per cent of time, i. e., for half the time the flow will be below and for half the time above the 50-per-cent-time flow. This flow has been variously called the "characteristic mean discharge," "normal discharge," "medium discharge," "ordinary discharge." It is believed, however, that the term "50-per-cent-time flow" should be used because of its definiteness.

(3) Power available 90 per cent of time on the assumption of the highest economic utilization of such storage sites as are known to exist or may reasonably be expected to exist.

(4) Power based on complete utilization.

The horsepower equivalents of capacities in kilowatts will be shown in parentheses following the values in kilowatts, or the ratio between the horsepower and kilowatt will be frequently expressed.

The computation of power will be based on 100 per cent efficiency using gross head at the site, or if a stretch of river is considered, the total gross head which may be developed, gross head being considered as the difference in normal elevation of the pool created by the dam and the tail race.

Developed Sites

The rating of developed sites will show:

(1) Power of the site determined and expressed as though undeveloped.

(2) Manufacturers' ratings of limiting machine capacities, expressed in kilowatts.

This tentative rule not only will present a reasonably true picture of the resource to the non-technical as well as the technical user but also will provide a basis from which the engineer may compute with an error of less than 10 per cent the total annual output in kilowatt hours that may be expected and the increase in kilowatt hours obtainable from storage.

The accompanying duration curve of Tennessee River at Florence (Muscle Shoals), Alabama, based on mean weekly flows, 1898 to 1923, inclusive, illustrates the application of the rule to a concrete case.

F, G, H, J, L, Q—Lower part of duration curve for period of record,
J, K, O—Assumed lower part of curve with regulation,
H, I—50-per-cent-time flow,
L, M—90-per-cent-time flow natural,
K, M—90-per-cent-time flow with assumed regulation,
A, E—flow that will be used when ultimate installation is made as proposed,
B, E—mean flow for period of record—theoretical flow with complete regulation.

Assuming that power instead of flow is represented on the vertical axis, 100 per cent load and efficiency factors, and installation to point of 50-per-cent-time flows:

Area D L Q R E = reliable power in kilowatt hours obtainable in most years. This quantity may be computed with an error of less than 3 per cent by multiplying the 90-per-cent-time power by 8,760 (hours in a year).
C H L D = secondary power in kilowatt hours obtainable in most years. This quantity may be computed by multiplying the difference between the 90-per-cent and 50-per-cent-time power by 4,380 and adding thereto the product of one-half the difference between the 90-per-cent-time power and the 50-per-cent-time power by 3,504. The error in this computation will be only a few per cent represented by the area between the curved line H J L and the straight line H L.
K M × 8,760—power output obtainable with storage in most years.
K L × 8,760—increase in output of reliable power resulting from storage obtainable in most years.

These quantities may be obtained from the indices of the proposed rating with a degree of accuracy comparable to the base data.

The power represented by P Q will not be shown and, in fact, can rarely be determined since its determination requires a knowledge of the absolute minimum flow which is never known with certainty. At Muscle Shoals with 100-per-cent-time flow for the 25-year period through 1923 was about 7,500 second-feet, but during 1925 the flow dropped somewhat below 4,000 second-feet. Although the new low is nearly 50 per cent less than the previous low it has not greatly changed the 90-per-cent-time flow nor the value of Muscle Shoals as a power site. It seems doubtful, therefore, if a rating based on the new minimum would have considerable statistical value.

The rating will not show energy represented above the line C H which can be recovered only by (a) use of storage which is not available or not feasible of development, or (b) the installation of water wheels that will use the flow for less than 50 per cent of time. The ultimate development at Muscle Shoals will use the flow which is available for only 22 per cent of the time. Examination of the records of installed capacities of many recent developments indicates that this and even higher installations are the rule and not the exception. Decisions on the feasibility of wheel installations for short time use require a knowledge of load and other conditions not available for undeveloped power sites. If the rule finally adopted by the Committee uses mean flow as a measure of the absolute limit of theoretical energy, the technical user of the statistics will also be able to use this rate for defining further the upper portion of the duration curve. In the illustration used the energy represented by the area B G H C could be determined with a small error in the location of the point G with respect to time. The rating based on mean flow is also a closer index of probable future installations than the rating based on 50-per-cent-time flow, although, as previously stated, this feature may have little value.

Definitions

90-PER-CENT-TIME FLOW—The flow occurring at the site 90 per cent of the time considering the total period covered by the record. If the record covers one year there would be 36 days when the flow would be below the 90-per-cent-time flow; in a 10-year record there would be 365 days when the flow would be below the 90-per-cent-time flow. The rate may be determined from a duration or deficiency curve covering the period of record. The greatest accuracy is obtained by using mean daily flows, although reasonable accuracy may, perhaps, be obtained by using either mean weekly or mean monthly values or by inspection of the record without the preparation of curves.

50-PER-CENT-TIME FLOW—The flow occurring at the site for 50 per cent of the time considering the period covered by the record. If the record covers a period of one year there would be 182 days when the flow would be below the 50-per-cent-time flow and 182 days when the flow would be above. In a 10-year record there would be 1,825 days when it would be above and 1,825 days when it would be below the 50-per-cent-time flow.

MEAN FLOW—Flow obtained by the summation of the mean daily discharges in second feet for the period of record divided by the number of days covered by the record.

POWER WITH STORAGE—Power which could be obtained 90 per cent of the time assuming the highest economic utilization of such storage sites as are known or may be reasonably expected to exist. Although it is realized that for many rivers data are not available which will enable the determination of this rating, its importance is recognized by all.

POWER BASED ON FLOW WITH COMPLETE UTILIZATION—Power based on mean flow. This rate may be used for the determination of:

(a) The absolute theoretical limit of energy that could be obtained if all the run-off were conserved by storage without allowance for the necessary losses by evaporation from surfaces of storage reservoirs or by plant installations sufficient to utilize extreme flood flows.

(b) For roughly defining the upper part of the duration curve.

(c) As an approximate index of capacities of future installations.

WATT—Unit of work equal to 10^7 (10 to the 7th power) C. G. S. units of power or work done at the rate of 1 joule a second. (1 joule equals .7376 foot pounds per second.)

KILOWATTE—1,000 watts.

HORSEPOWER—(English and American) unit of work numerically equal to a rate of 33,000 foot pounds of work per minute (550 foot pounds per second.)

1 HORSEPOWER—745.7 watts.

1 KILOWATT—1.3405 horsepower.

GROSS HEAD—The difference in normal elevation of the pool created by the dam and the tail race, or if a stretch of river be considered on which surveys are not available, to determine the probable method of development, the total gross head which it is believed may be developed.

1 CUBIC FOOT OF WATER—62.355 pounds.

SECOND-FOOT—Quantity of water flowing in a stream 1 foot wide, 1 foot deep, at an average velocity of 1 foot per second.

THEORETICAL HORSEPOWER—Gross head in feet × discharge in second-feet × 62.355 ÷ 550 equals H × Q × .11337.

THEORETICAL KILOWATT—Head × flow × .08454.

Electrified Steam Railroads—1927

Line	*(1927) Miles Electric Track*	*Trolley Voltage*	*Kind of Service, Passenger or Freight*	*Power from*	*(1927) KWH at Power House for Trains*	*Reasons for Not Using Water Power*
Great Northern R. R...	25	11000 AC	P & F	Water	16,202,098	
Penna. System:						
New York Terminal...	110.8	650 DC	P	Coal	108,390,010	Economic
Philadelphia Terminal.	124.65	11000 AC	P	Coal	48,708,600	None available
West Jersey & Seashore.	150.38	650 DC	P	Coal	39,987,600	None available
Detroit, Toledo and Ironton..............	50.046	23000 AC	F	Coal	6,000,000	None available
Erie Railroad..........	38	11000 AC	P	Water	2,034,050	
Baltimore & Ohio:						
Belt Line Railroad....	8.7	660 DC	P & F	C & W	7,576,850	
Staten Island..........	49.5	650 DC	P	Coal	14,629,219	None available
Michigan Central.......	28.5	600 DC	P & F	Coal	7,060,000	None available
Southern Pacific:						
East Bay Div.........	98	1200 DC	P	Fuel oil	28,634,400	Economic
Portland Div..........	147.4	1500 DC	P	Water	8,506,500	
Butte, Anaconda & Pacific..............	123	2400 DC	P & F	Water	19,252,657	
Chicago, Milwaukee & St. Paul R. R.......	878.5	3000 DC	P & F	Water	141,862,841	
Boston & Maine:						
Hoosac Tunnel........	21.38	11000 AC	P & F	Water	7,398,000	
Long Island R. R.......	356.84	650 DC	P & F	Coal	176,200,000	None available
	84.92	11000 AC	F	Coal	4,343,000	None available
Norfolk & Western R. R.	209.54	11000 AC	P & F	Coal	72,846,128	None available
N. Y. N. H. & H. R. R..	554.60	11000 AC	P & F	Coal	160,105,100	None available
Illinois Central.........	126.199	1500 DC	P	Coal	52,646,813	None available
New York Central.....	326.64	660 DC	P & F	Coal & fuel oil	166,000,000	None available
Canadian National:						
Mount Royal Tunnel..	32.2	2400 DC	P	Water	2,688,320	
St. Clair Tunnel......	15.5	3300 DC	P & F	Coal	3,753,017	Little water power available
Virginian Railroad......	230.20	12000 AC	F	Coal, pulverized	107,966,440	None available
Total..................	3790.495				1,203,291,000	

Power generated by:	KWH
Fuel Oil..............................	28,634,400
Water Power..........................	201,444,200
Coal..................................	973,212,640

Note.—The Wilmington-West Chester Line of the Pennsylvania Railroad System has under construction at the present time 150.06 miles of electrified track. The trolley voltage will be 11,000 volts A. C. 25 cycles, and the line will be used exclusively for suburban passenger traffic.

The Reading Railroad Company contemplates electrification of suburban lines in the vicinity of Philadelphia. This will be 11,000 volts, 25 cycles, Multiple Unit passenger service, power being generated by steam plants burning coal.

Conclusions

It is recommended that the report be considered as information, and the subject continued.

Appendix D

(4) ELECTROLYSIS

H. A. Currie, Chairman, Sub-Committee; H. C. Cross, Vice-Chairman, Sub-Committee; Paul Lebenbaum, C. G. Lovell, W. P. Monroe, H. P. Wright.

AMERICAN COMMITTEE ON ELECTROLYSIS

There have been no meetings of the American Committee on Electrolysis nor of the Sub-Committee on Research since the report of October, 1927, was submitted.

The Sub-Committee on Research reported that arrangements have been made by the Bureau of Standards in connection with their Soil Corrosion Investigation to remove specimens of bare iron and steel pipe buried at different localities in 1922. After all samples had been collected an opportunity would be had to inspect them at the Bureau of Standards, in Washington, D. C.

MITIGATION OF ELECTROLYSIS ON THE ILLINOIS CENTRAL RAILROAD CHICAGO TERMINAL ELECTRIFICATION

Steps Taken in Design of Negative Return System

When the rail return system was being designed, a careful study was made of the probable potential gradient on all portions of the system, with the view toward limiting the potentials so that they would conform with the Street Railway Ordinance for Prevention of Electrolysis. While it is generally agreed that this ordinance does not apply to electrified steam roads, it was considered wise, from the standpoint of protection to the railroad's own property as well as freedom from litigation, to conform as closely to the conditions of the ordinance as was economically possible.

With this in mind the present return system, with all electrified tracks bonded and two non-electrified tracks bonded between Twelfth Street and 67th Street, was designed.

Measurements made on the Chicago Terminal indicate that even under abnormally wet conditions the resistance from rail to earth would be at least one ohm per thousand feet. In dry weather this resistance would be from five to ten times greater. The ordinary street railway rail has a resistance to earth of about one-tenth of these values. It was hoped that this high standard of insulation of the return system from earth could be kept up by isolating the rails from all grounded structures and surface line rails. This has not been possible, however, due to grade crossings with street railways and the lack of a reliable spark gap which would give positive protection in case of a short circuit but still normally isolate the rails from grounded structures.

Steps Taken Since Starting Electric Operation

While it was originally planned to drain all feeder and telephone cables, the actual connections, outlined below, were not made until after electric operation had started. At each substation the current is drained off of the lead sheaths of all cables entering the substation as well as from the Illinois Central and Western Union Cables which run along the right of way. All cables are drained into a drainage bus, which is connected through an ammeter to the negative bus of the machine. As an additional safeguard a drainage cable is run in parallel with the feeder cable sheaths from the substation to the feeder structure manhole.

Drainage connections are also run to Bell Telephone Cables from Cheltenham Substation and to the South Park Commissioners' cable from 16th Street Substation. Additional drainage connections are contemplated to Bell Telephone Cable systems at all substations, and will probably be installed in the near future.

At Markham Yard the pneumatic tube system has been interconnected with the water pipes, and the whole circuit connected to the drainage cable in the feeder structure manhole at Harvey Substation. This connection was made as a result of electrolysis measurements taken since electric operation began, which indicated that such a connection would be desirable.

Insulating joints are being installed in the conduits which run from catenary structures and which are connected to the rail or to earth. This step was found to be necessary because of burning of conduit fittings by stray currents leaking from rail to earth by way of catenary structure and conduit.

Periodic Tests to Determine Electrolysis Conditions

(a) Every six months a survey is made of the relative current flow at various locations along the telephone cable sheaths on the right of way in order to see whether or not current is leaving at any place other than where drainage cables are provided.

(b) Recording ammeter charts are taken of the current in drainage connections every six months.

(c) Recording meter charts are taken of the potential of rails above earth at points midway between substations every six months.

(d) A survey of the electrolysis conditions of the Markham Yard tube and water system, including recording meter charts of the drainage current, is made every three months.

(e) General potential and current measurements are taken from time to time between the public utility companies' underground structures and the rails to determine the general electrolysis conditions near the right of way.

Conclusions

(1) That representation on the American Committee on Electrolysis be continued.

(2) That the subject of Mitigation of Electrolysis on the Illinois Central Railroad Chicago Terminal Electrification be accepted as information.

Appendix E

(5) CO-OPERATION WITH U. S. BUREAU OF STANDARDS

W. L. Morse, Chairman, Sub-Committee; F. Auryansen, Vice-Chairman, Sub-Committee; B. F. Bardo, J. H. Davis, J. V. B. Duer, J. T. Seaver, Z. H. Sikes, L. S. Wells.

There have been no meetings of the Sub-Committee and no conferences with the U. S. Bureau of Standards during the past year.

The representatives of the American Railway Association have been negotiating with the National Electric Light Association in accordance with the authority conferred on them by letter from the President dated July 8th, 1927, looking towards the establishment of a set of Principles and Practices covering crossing of power wires over railroads. The preparation of these principles and practices has reached the point where they are apparently satisfactory from the standpoint of the railway representatives and the representatives of the National Electric Light Association are now considering the matter with a view to deciding whether or not they are satisfactory to them. It is felt that the matter is progressing satisfactorily.

From records which have been compiled and are on file in the office of the Secretary of the Telegraph and Telephone Section, A.R.A., 44 power wire crossing failures occurring between May, 1922, and March, 1927, and reported by 17 railroads, members of the American Railway Association, are listed below:

(See attached table.)

Reports of additional power wire crossing failures, when received, will be sub-divided into three sections as follows:

(a) Failures due to broken supports or poles.
(b) Failures due to insufficient, or lack of, guying.
(c) Failures due to broken wires.

By keeping a continuous record of these failures it is hoped that valuable information will be obtained that will be helpful in the standardization of specifications for power wire crossings over railroads.

Conclusions

That the report of the Committee be accepted as one of progress and that the work be continued in co-operation with the U.S. Bureau of Standards for the revision of the National Electrical Safety Code under the procedure of the American Engineering Standards Committee, now known as the American Standards Association, for any part of the code that may be reopened or, in the specifications for Supply Lines Crossing Railroads and with representatives of the National Electric Light Association in the preparation of a general agreement as to principles and practices, with accompanying specifications, covering power wire crossings of railroads, to be made the standard of both associations.

Power Wire Crossing Failures Occurring Between May, 1922, and March, 1927

		CLEARANCES			NATURE OF FAILURE				
	NO.	FROM GROUND	WIRES OF OTHER LINES	BETWEEN POWER WIRES	POLES	WIRES	SAGS	TIES	CAUSES
Atch.Top. & SantaFe	1	42 ft.	25 ft	36 in.		1			Wire partly burned, due to soot and fog
	1	33 "	4 "	34 "	Leaning		Yes		Wires not in position to hold strain
	1	42 "	25 "			1	0	0	Soot on insulator and fog
	1	30 "	12 "			Stk.Guy			
	1	32 "	16 "	72 "		1	2ft.		Defective wires
	1	30 "	15"	15 "		Stk.Guy			Crossing pole supported by self supporting stub
	1	24 "	12 "		1				Wind broke defective pole
	1	30 "	6 "	48 "			0	0	Three wires burned
Baltimore & Ohio	1	30 "	10 "	14 "		1			Wind storm
Canadian National	1	38 "	15 "	15 "	0	2			Two power wires swung together, burned and dropped
	1	30 "	20 "	18 "		2	0	0	Falling tree - Wind 40 m.p.h.
Cent.R.R. of N.J.	1		30 in.		Rotted				
	1	35 "	4 ft.				Excessive		
Chic.Mil.& St.Paul	1	27 "	2 "	18 "		2			Storm - Wind 50 m.p.h. - One man killed
	1	30 "	8 "	48 "	2	0	0	0	Wind 45 m.p.h.
	1	22 "					Contact		Poor construction
	1	28 "		12 "			Yes		" "
	1	28 "	2 "	92 "		1			Rust and wind
Florida East Coast	1	27 "	5 "						Cart backed into guy pulling out serving wires
Great Northern	1	35 "	25 "		1				Pole fell during erection
Illinois Central	1	35 "	4 "	24 "	0	2	8 in.	0	Wind 45 m.p.h.
	1			60 "		2			Crossing span slacked - contact with trees
Indiana Harbor Belt	1	25 "	2 "	16 "					Carelessness of workmen - grounds in protectors
Kansas City Southern	1	30 "	5 "	14 "					Weak crossing poles, no guys - wind 40 m.p.h.
	1	40 "	20 "	16 "	1				Decayed crossing poles
Michigan Central	1	35 "	3 "	24 "		Yes	0	0	Kite crossed two supply lines
Miss.Kansas-Texas	1	30 "	5 "	12 "	1	1	0	0	Storms and wind
N.Y.N.H. & H.	1	34 "	15 "	12 "	0	0	1 wire 4 ft.	0	Wire never pulled to proper clearance
	1	45 "	10 "	12 "	0	1	0	0	Wind 50 m.p.h. - no ice.

	NO.	CLEARANCES FROM GROUND	CLEARANCES WIRES OF OTHER LINES	CLEARANCES BE-TWEEN POWER WIRES	NATURE OF FAILURE POLES	NATURE OF FAILURE WIRES	NATURE OF FAILURE SAGS	NATURE OF FAILURE TIES	CAUSES
Pennsylvania	1	31 "	11 "			1			Wind 90 m.p.h.
	1								
	1	28 "	6 "	12 "		2burned	12 in.	0	Wind 60 m.p.h.
	1	25 "	10 "			2			High wind
	1	18 "	22 "	14 "		1	0	0	Falling derrick
	1	28 "	6 "	12 "		3	1 ft.	0	Sleet or snow - wind 60 m.p.h.
	1	45 "	1.5"	30 "		Yes	0	0	Wind 60 m.p.h.
	1	25 "	5 "				Slight	0	Defective poles - snow load - broke other wires
(P.O.& D.)	1	36 "	16 "	14 "		2			Lightning broke insulators
St.Louis San Francisco	1	30 "	15 "	30 "		1	0		Branch line tapped main line
	1	35 "	10 "	30 "		1	0	0	Wire tapped in middle of span weakened in wind storm
Southern	1	30 "	4 "	12 "	1	0	8 in.	0	Strong wind and snow, no ice
	1	28.5"	1.3"			0	Yes		Improperly strung wires
	1	35 "	8 "	96 "		0	0	0	Wind
Wabash	1	30 "	10 "	36 "		2		0	Heavy sleet storm

Appendix F

(6) OVERHEAD TRANSMISSION LINE AND CATENARY CONSTRUCTION

L. S. Wells, Chairman, Sub-Committee; G. I. Wright, Vice-Chairman, Sub-Committee; F. Auryansen, B. F. Bardo, H. M. Bassett, J. C. Davidson, J. V. B. Duer, F. D. Hall, P. S. Mock, R. J. Needham, H. Pattison, J. A. Peabody, H. W. Pinkerton, J. E. Sharpley, R. P. Winton, Sidney Withington.

The following work is under consideration by this Sub-Committee: "Revise and keep up to date the transmission line and catenary specifications."

1. The Sub-Committee has considered the transmission line specifications previously adopted and has no changes or additions to recommend at this time.

2. As a result of criticisms and suggestions received, concerning the preliminary draft of the "Specifications for Catenary Construction for Railroad Use," several revisions have been made as shown in detail below by specification sections. Matter within parenthesis is to be omitted and that underlined is to be added:

2. Definitions

Catenary Suspension—The term catenary as used in these specifications means all forms of suspension of overhead contact systems in which the contact member is supported at more or less regular intervals by one or more messenger cables to produce a contact surface nearly parallel to the top of track rail.

Classifications—. . . Under alinement there are two general types, (tangent) chord construction and inclined construction.

(Tangent) Chord Catenary—is that construction in which, on curves, the catenary is the same as on tangent, suitably deflected at proper intervals.

Inclined Catenary—is that type in which, on curves, the messenger system not only supports the vertical load but also carries the horizontal load reaction of the entire system, the hangers assuming the direction of the resultant force on the contact wire.

Double Catenary—is that construction consisting of one or more contact wires, with auxiliary conductors if used, supported by triangular or V hangers from two . . . .

Contact System

The Contact Wire—is the wire (member) with which sliding or rolling contact is made by the current collecting device.

Single contact type consists of but one conductor which is the contact wire. . . .

Supporting Structures

Included with the supporting structures are steady braces and steady spans. A Steady (Brace) is a (rigid) member (normally unstressed) connecting the contact or messenger wires to the supporting structure. (A Steady Span is the flexible member used with bridge or cross span construction between supports to) in order to steady them (either the messenger wire or the contact wire.)

Insulators

Insulators in all cases are considered to be a part of that portion of the catenary system with which they are used.

3. Preliminary Considerations

(e) Conduct a complete survey of the physical roadway property involved in the electrification so that preferred locations and types of construction for supporting and guying structures may be determined with due regard to physical obstructions, nature of soil, possible future improvements, signals, signal control lines, communication lines, smoke or atmospheric conditions, and other local considerations.

8. Clearances at Highways, Canals, Creeks and Navigable Streams

The clearances of line (over) from the ground and at buildings, highways, canals, creeks and navigable streams will depend on local conditions and shall be in compliance with Federal, State and local requirements.

10. Heavy Catenary Loading (H)

....

Note.—The weight of ice shall be assumed as 57 lb. per cu. ft. (.033 lb. per cu. in.)

25. Clamps, Sockets, Turnbuckles, Miscellaneous Hardware

(b) Sockets may be of bronze (Malleable) malleable iron or steel, ...

26. Section Breaks for Contact Wire

. . . . Where it is difficult to install the (overlapping) air section break, such as over crossovers, yard tracks, or siding tracks (the non-overlapping), a type of break with metal gliders may be used. The insulation used in both types of breaks may be wood, porcelain or other approved material.

30. Any Direction

(b) At intervals, preferably not more than one mile, suitable anchorages for the (catenary) messenger shall be provided. With . . . .

31. Material

. . . . Poles shall have a nominal top diameter of not less than 7 inches. The use of treated poles to resist deterioration is recommended.

35. Material and Designs

. . . . The design of the structure shall be such that all (reinforcement) steel is (completely) covered by (the) at least 2 inches of concrete.

36. Strength of Guys and Anchors

(c) Rigid steel structures should not be guyed except under special conditions in which case (an investigation of the stresses should be made) provision should be made for any increased stresses.

The catenary specification has been amplified by the addition in an exhibit of diagrams illustrating various combinations of the different component parts of catenary construction which are, at the present time, in general use. These diagrams are attached.

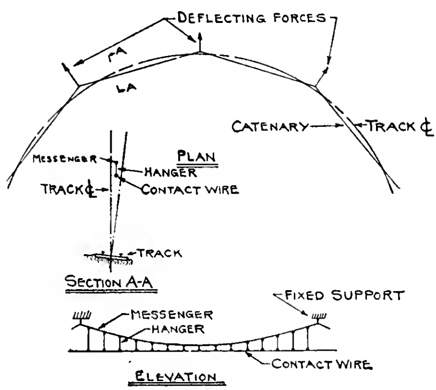


Fig. 1—Chord Catenary

Consideration has been given to the recommendations as to flash-over values for insulators and the Sub-Committee is engaged in studies for clarification and amplification of these items which it is hoped will be completed next year.

The Sub-Committee has made a preliminary investigation of the subject of detailed specifications for component parts of catenary construction, and while this work has been advanced in a preliminary way, the Sub-Committee is not yet in a position to submit such specifications in any tentative form.

Inasmuch as the work of Sub-Committee No. 5, jointly with the National Electric Light Association, in the preparation of wire crossing specifications satisfactory to the railroad, has not been concluded, the preliminary draft of the catenary specification must be held open for further revision. The Sub-Committee feels, therefore, that further consideration of the specification should be deferred until such time as this work is concluded.

Conclusions

It is recommended that this subject be continued.

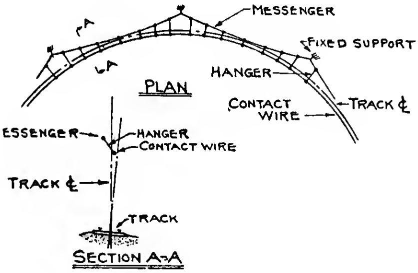


FIG. 2—INCLINED CATENARY

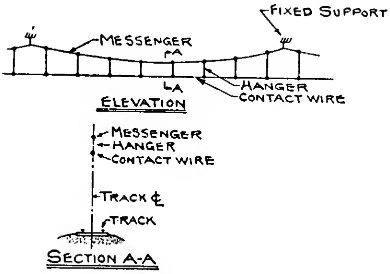


FIG. 3—SINGLE CATENARY

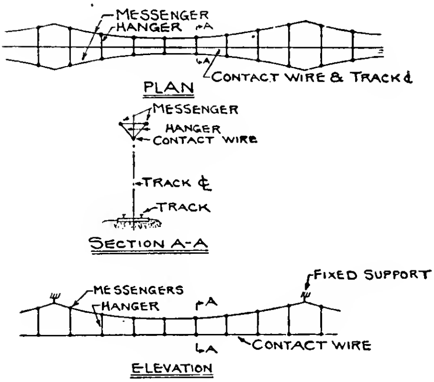


FIG. 4—DOUBLE CATENARY

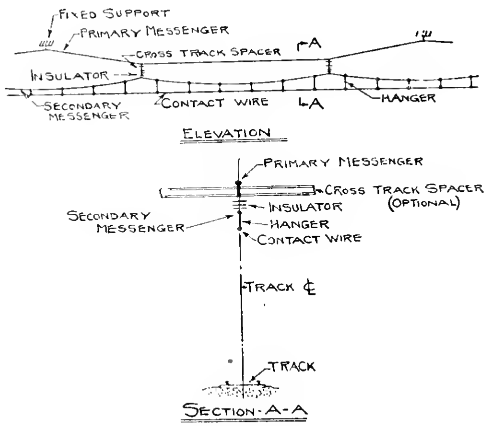


FIG. 5—COMPOUND CATENARY

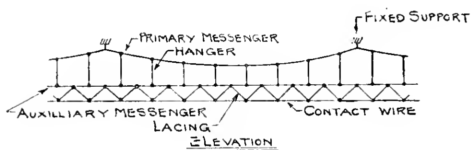


FIG. 6—CATENARY WITH AUXILIARY CONDUCTOR AND LACING

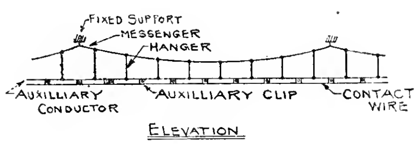


FIG. 7—CATENARY WITH AUXILIARY CONDUCTOR

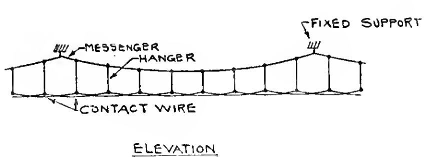


FIG. 8—CATENARY WITH TWIN CONTACT WIRES

Appendix G

(7) COLLABORATION WITH COMMITTEE XVI—ECONOMICS OF RAILWAY LOCATION

D. J. Brumley, Chairman, Sub-Committee; J. C. Davidson, Vice-Chairman, Sub-Committee; H. M. Bassett, J. V. B. Duer, A. E. Owen, J. A. Peabody, H. W. Pinkerton, H. M. Warren, C. G. Winslow.

Sub-Committee No. 2 of Committee XVI—Economics of Railway Location, has prepared an excellent report on the design of locomotives with particular reference to the major considerations affecting such design. It probably is not within the province of any of the working committees of the American Railway Engineering Association to prepare designs of locomotives but it seems it would be proper for the Committee to make suggestions with reference to the consideration governing such designs.

It is the recommendation of Sub-Committee No. 7 that after a discussion of the report of Sub-Committee No. 2 of Committee XVI, Economics of Railway Location, the data be referred to the Joint Committee on Electric Traction.

Conclusions

It is recommended that collaboration with Committee XVI be continued.

Appendix H

(8) STANDARDIZATION OF INSULATING TAPES

H. M. Warren, Chairman, Sub-Committee; P. Lebenbaum, Vice-Chairman, Sub-Committee; H. M. Bassett, R. Beeuwkes, J. H. Davis, C. B. Martin, J. L. Minick, M. Schreiber, G. I. Wright.

The following work was assigned to this Sub-Committee:

The study of insulating tapes, with especial reference to varnished cambric and paper tapes.

1. Varnished Cambric Tape

The Insulated Power Cable Engineers' Association are working on the preparation of specifications for varnished cambric insulated wires and cables which should soon be completed. These specifications will doubtless contain much information that will be valuable to this Sub-Committee. Also, Committee D-9 of the American Society for Testing Materials is preparing specifications covering methods of testing varnished cloth tapes. These specifications are still under discussion and have not been reported out of the Committee. An advance copy, however, of these proposed specifications has been obtained. These specifications describe how measurements of thickness, mechanical and electrical strength, resistance of oil, etc., shall be made. In the preparation of the proposed purchase specification it will be necessary only to specify the desired quality of the tape and refer to

A.S.T.M. methods for determining whether the manufacturer has met the specifications. It is apparent that the specifications when completed will be of the greatest help to this Sub-Committee, and any specification which we prepare should be timed to follow and not precede them, so that full advantage can be taken of their work. In the meantime the Sub-Committee has received and examined samples of varnished cambric tape of various thicknesses and types of manufacture. The Sub-Committee, therefore, at this time can only report progress.

2. Paper Tape

This specification will cover impregnated paper tape to be used in insulating the joints in paper insulated cables. In a general way it is good practice to secure from the manufacturer, when ordering paper insulated cable, sufficient impregnated paper tape such as was used in manufacturing the cable, and make use of such tape in insulating the joints. At a later date, however, it may be necessary to secure additional impregnated paper tape and to order such tape by specification. Some attention has been given to this subject, but the work has not advanced sufficiently for an extended report.

Conclusions

It is recommended that work on the preparation of these specifications be continued.

Appendix I

(9) STANDARDIZATION OF INSULATORS

F. D. Hall, Chairman, Sub-Committee; B. F. Bardo, Vice-Chaimran, Sub-Committee; J. V. B. Duer, R. J. Needham, M. Schreiber, H. M. Warren, G. I. Wright.

Assignments

1. Revise and keep up to date the Insulator Specification as adopted.
2. Investigate insulators made of boro-silicate glass.

The following action has been taken:

1. The Sub-Committee does not believe that a revision of the Specification should be made at this time. Some changes in definition have been proposed by the Insulator Committee of the American Institute of Electrical Engineers and have been approved by Committee XVIII. These changes will be included in a future revision of the specification.

2. The Sub-Committee has investigated the use of insulators made of boro-silicate glass and is of the opinion that pin insulators of proper design made of this material are suitable for transmission lines.

Conclusions

It is recommended that this subject be continued.

Appendix J

(10) CLEARANCES FOR THIRD RAIL AND OVERHEAD WORKING CONDUCTORS

H. M. Bassett, Chairman, Sub-Committee; C. G. Winslow, Vice-Chairman, Sub-Committee; F. Auryansen, D. J. Brumley, F. D. Hall, G. Hamilton, A. E. Owen, P. S. Mock.

No new diagrams or tables as to clearances for third rail or overhead working conductors are submitted this year, as these data, which are submitted every two years to the Association, were reported upon as of November 1, 1927. The usual steps will be taken in 1929 to review these data and to bring them before the Association as of November 1, 1929.

The Sub-Committee has worked as closely as possible with Sub-Committee No. 6 in the preparation of their Transmission Line and Catenary Specifications, but no definite conclusions as to new clearances have been determined. It was decided at the August meeting of the Committee of Direction of the Electrical Section that progress was not to be expected from Sub-Committee No. 10 until the Special Committee on Clearances had acted.

The Chairman of Sub-Committee No. 10 attended the meeting in Buffalo on October 11th of the Special Committee on Clearances, and as a result of their activities the Committee on Electricity will probably be requested in 1929 for some further study on Clearances.

Conclusions

It is recommended that this subject be continued.

Appendix K

(11) PROTECTION OF OIL SIDINGS FROM DANGER DUE TO STRAY CURRENTS

L. C. Winship, Chairman, Sub-Committee; W. P. Monroe, Vice-Chairman, Sub-Committee; J. V. B. Duer, Paul Lebenbaum, J. T. Seaver, Sidney Withington.

The Sub-Committee has carefully considered the revision of the Rules for Protection of Oil Sidings from Danger Due to Stray Currents, adopted in 1924 by the American Railway Engineering Association.

From the information which has been gathered during the year it appears advisable to present a new draft of these Rules for consideration in 1929, this draft to include Rules for Protection from Danger Due to Static Electricity.

Conclusions

It is recommended that this subject be continued.

Appendix L

(12) SPECIFICATIONS FOR TRACK AND THIRD RAIL BONDS

J. H. Davis, Chairman, Sub-Committee; J. S. Hagan, Vice-Chairman, Sub-Committee; F. Auryansen, J. V. B. Duer, A. Knapp, Paul Lebenbaum, S. R. Negley, J. A. Peabody, J. T. Seaver, W. M. Vandersluis, L. S. Wells, R. P. Winton, Sidney Withington.

In the Sub-Committee's report of last year four of the five subjects assigned to it were completed but the Study of Details of Bond Design with a View to Developing Specifications Covering the Different Classes of Bonds was carried over and is included in this year's assignment. In addition, the following subjects were assigned to the Sub-Committee:

Collection of information as to methods and extent of practice in reapplying bonds.

Collection of data on compositions used, if any, on rail joints to replace bonds.

Study of contact areas and resistances for different types of bonds.

Compiling information concerning rail joint clearance and its effect on rail bond design.

1. Study of details of bond design with a view to developing specifications covering the different classes of bonds. The report of last year pointed out the advantages of rail bond standardization and suggested features that might be standardized for pin terminal bonds. It also suggested that in the case of gas welded bonds, which are coming more and more into general use for heavy traction purposes, many of the limitations in the design of pin terminal bonds do not exist and aside from certain major features the necessity for standardization of heat applied bonds is not as important as with bonds of the mechanically applied type. In addition to standardizing the size of the wires, number of wires in strand and the lay of strand for various capacities of heat-applied bonds further studies are being made with a view to developing the lengths for different sizes of heat-applied bonds and their general form to provide for expansion and contraction. These studies will include different types for one and two bonds per joint. The general form and material of terminal, contact areas for various sizes, characteristics of welding rods and other general features of this nature may upon further study be standardized. The matter of rail joint clearances also affects rail bond design and until further study is given to these various subjects the Sub-Committee can only report progress.

2. Collection of information as to methods and extent of practice in reapplying bonds. The Sub-Committee has been supplied with returns from a questionnaire on this subject which was sent out by the Bond Committee of the American Electric Railway Association, a summary of the replies and tabulation of detailed answers being included in the Heavy Electric Traction Committee's report of this year to which reference should be made

for detailed information. The following questions were asked of twenty railroads, involving twenty-one electrified sections:

(a) "Do you make it a practice to remove and reapply bonds?"

Sixty-six per cent advise that bonds are not reapplied, 24 per cent make it a practice to reapply bonds and 10 per cent do so only in exceptional cases.

(b) "Why is the practice of reapplying bonds not followed?"

Twenty-four per cent reply that the bonds are destroyed by removal, 19 per cent reply that it is poor economy, 14 per cent reply that bonds are not adapted for reapplication, 5 per cent that reapplied bonds give unsatisfactory results, 5 per cent state that additional hole in the rail will be required and 33 per cent give no direct answer to the question.

(c) "If you do not follow this practice now, did you ever do so in the past and why was it discontinued?"

Seventy-six per cent give no direct answer to the question, 14 per cent advise that they reapply pin terminal bonds but not welded bonds, 5 per cent state that unsatisfactory results caused them to discontinue the practice of reapplying bonds, 5 per cent report that they cannot reapply bonds because they are of the compression type.

(d) "How are bonds reconditioned after removal to fit them for reapplication?"

Twenty-nine per cent report that they reshape or replace the bond terminals, 5 per cent report that compressed bonds are drilled for pin terminal bonds, 66 per cent give no direct answer to the question.

(e) "What special method do you follow in making the second application that is different from the initial operation?"

Nineteen per cent report the use of larger drift pins for reapplication of bonds, 5 per cent advise that bond is compressed for first application and driven for the second application, 76 per cent give no direct answer to the question.

(f) "Have you noticed any reduction in life due to this procedure?"

No reduction in life of reapplied bonds was reported by any who used them.

Unless great care is exercised in reapplication of bonds of both mechanically and heat applied types there is probability of increased joint resistance as compared to the application of new bonds.

3. Collection of data on compositions used, if any, on rail joints to replace bonds. The Sub-Committee has been unable to obtain any accurate information as to the results obtained on the use of compositions on rail joints to replace bonds. It is understood that during the war a process was developed in Germany of spraying the ends of rails with molten tin so as to make the use of copper bonds unnecessary, the process consisting of sand blasting the rails and joint plates and spraying tin on the cleaned surfaces after which the rail joint was made in the usual manner. The Sub-Committee knows of no installation of this character in this country, but understands that a test of a few joints of this nature is contemplated by one road. The subject should be continued and an effort be made by the Sub-Com-

mittee to obtain accurate data on the results obtained in this country and abroad where this method of completing the return circuit without the use of bonds is being used.

4. Study of contact areas and resistances for different types of bonds. The manufacturers carried out tests a few years ago to determine the contact resistance between clean copper and steel surfaces at various pressures in connection with mechanically applied bonds. At a pressure of 30,000 pounds per square inch the resistance is .000,000,76 ohms per square inch and this resistance is not materially reduced at higher unit pressures. At lower unit pressures the contact resistances as determined by test are as follows:

Pounds Pressure per Sq. Inch	*Contact Resistance per Sq. Inch of Surface Ohms*
30,000	.000,000,76
20,000	.000,001,20
10,000	.000,002,90
5,000	.000,004,80

The actual contact resistance of a 1-inch diameter pin terminal bond applied to the web of a rail $\frac{9}{16}$ inch thick with clean surfaces and at a pressure of 30,000 pounds per square inch is .000,000,4 ohms. With a ½ inch diameter pin terminal bond the theoretical contact resistance is .000,000,8 ohms.

Since the theoretical values of contact resistance are so low as to be almost negligible, it is evident that the theoretical resistance of properly applied bond terminal as a whole depends upon the cross-sectional area and length of current path through the terminal, which afford appreciable resistance. From the standpoint of conductivity the cross-sectional area of the bond terminal should be such that the resistance per unit length through the terminal should be no greater than that of the bond cable. In the ordinary design of pin terminal bonds the diameter of the terminal is fixed by mechanical considerations and the resistance of the pin usually is less per unit length than that of the remainder of the bond.

While the above figures indicate that contact resistance is so low that it is unimportant, it is well known that in practice contact resistance often is so high as to seriously affect the return circuit resistance when bonds are not properly applied. The importance of good workmanship in the application of the bond to the rail is generally recognized but often neglected. If the holes in the rail into which bonds are to be applied are oversize (which will result in reduced contact pressure) or if the contact surfaces are not cleaned before application of bonds the contact resistances are indeterminate and may be of any value. Amalgamation of terminals does not reduce contact resistance of properly applied bonds. It may be effective for a short time in reducing the resistance of improperly applied bonds but is of doubtful value.

Where welded bonds are used the resistances are widely variable, depending upon the form of bond terminal, the composition of the welding rod and the amount of welding metal used in their application. Tests have been recently conducted by the bond manufacturers to determine the specific resistances of both steel alloy and copper alloy welding rods. Certain information has been supplied the Sub-Committee in this connection but the work has not progressed to the point that results can be made available in useful form. It is recommended, therefore, that this subject be continued with a view to determining the contact resistances of welded bonds with different types of welding rod and the cross-sectional areas of welds which should be used.

5. Compiling information concerning rail joint clearance and its effect on rail bond design. Rail joint design has a strong influence on bond design, not only from the standpoint of use of concealed bonds but also heat-applied bonds to the side of head of the rail within the limits of the angle bar. Types of bonds for traction purposes in general use today are of the so-called straight weld, U type weld and pin terminal. The straight weld varies in length from 8 inches to 15 inches and is applied to the outside edge of the rail head above the angle bar. There is usually a slight expansion loop allowed so that it will not lie directly against the rail head the full length of the bond.

The U type, as its name implies, is built for application to the outside edge of the rail head and lies between two middle bolts of the angle bar. Its application is affected largely by the type of angle bar and the distance between the middle bolts. The elevation of the outside edge of the angle bar on a good many of the reinforced types is such as to prevent its satisfactory application.

Pin terminal bonds are usually applied either above or below the bolts between the outside splice plate and the rail web. Any bond intended for installation outside of the splice plates by any method is entirely outside of this consideration.

Typical rail section and splice bar plans have been obtained from fourteen railroads either having electrified sections in service or who may be contemplating electrified sections. It is apparent from a study of the detailed rail joint plans submitted that there is little or no opportunity (assuming concurrence of the Rail Committee) to modify the contour of the angle bars so as to avoid "pinching" resulting in premature failure of concealed bonds as the joint deflects under load. As nothing further can be accomplished in the study of this matter it is recommended that the subject be discontinued.

Conclusions

That the subject be continued, with reference to:

1. Study of details of bond design with a view to developing specifications covering the different classes of bonds.

2. Collection of data on compositions used, if any, on rail joints to replace bonds.

3. Study of contact areas and resistances for different types of bonds.

Appendix M

(13) ILLUMINATION

L. S. Billau, Chairman, Sub-Committee; J. H. Van Buskirk, Vice-Chairman, Sub-Committee; H. A. Currie, J. V. B. Duer, C. B. Martin, J. L. Minick, R. J. Needham, A. E. Owen, L. C. Winship, S. Withington.

The following subjects were assigned to the Sub-Committee:

(1) Revision of the incandescent lamp schedules to bring them up to date and to include a schedule of miniature lamps recommended for railroad use.

(2) Preparation of specification for incandescent lamps.

(3) Continuation of the study of floodlighting for classification yards and other railroad purposes.

(1) INCANDESCENT LAMP SCHEDULES

1. The Sub-Committee has reviewed and revised the Incandescent Lamp Schedule as it appeared in Bulletin 301, November, 1927, as indicated in the accompanying schedule of Incandescent Lamps. The principal changes are as follows: The adoption of the inside frosted lamp in the General Lighting and Train Lighting Groups as standard; a reclassification of the Rough Service Group; the addition of a 250-watt lamp in the G-30 bulb and a 500-watt lamp in the G-40 bulb, in the Floodlighting Group; the substitution of 36-watt A-21 and 56-watt A-21 lamps for the same size lamps in the S bulbs in the Street Railway Lighting Group; the addition of a Flashlight Service Group; and a revision of the Motor Coach Lighting Group.

Incandescent Lamp Standards—1928

General Lighting Service

Watts	*Voltages*	*Bulb*	*Base*
15	110, 115, 120, 125	A-17	Med.
25	110, 115, 120, 125	A-19	Med.
40	110, 115, 120, 125	A-21	Med.
50	110, 115, 120, 125	A-21	Med.
60	110, 115, 120, 125	A-21	Med.
75	110, 115, 120, 125	A-23	Med.
100	110, 115, 120, 125	A-23	Med.
150	110, 115, 120, 125	PS-25	Med.
200	110, 115, 120, 125	PS-30	Med.
300	110, 115, 120, 125	PS-35	Mog.
500	110, 115, 120, 125	PS-40	Mog.
750	110, 115, 120, 125	PS-52	Mog.
1000	110, 115, 120, 125	PS-52	Mog.

High Voltage Lighting Service

Watts	*Voltages*	*Bulb*	*Base*
25	220, 230, 240, 250	A-19	Med.
50	220, 230, 240, 250	A-21	Med.
100	220, 230, 240, 250	A-23	Med.
200	220, 230, 240, 250	PS-30	Med.
300	220, 230, 240, 250	PS-35	Mog.
500	220, 230, 240, 250	PS-40	Mog.
750	220, 230, 240, 250	PS-52	Mog.
1000	220, 230, 240, 250	PS-52	Mog.

Rough Service

Watts	*Voltages*	*Bulb*	*Base*
50	110, 115, 120, 125	A-19	Med.
50	220, 230, 240, 250	A-21	Med.

Recommended for use in extension cord service.

Limited Lighting Service

Watts	*Voltages*	*Bulb*	*Base*
50	110, 115, 120, 125	P-19	Med.

Recommended for use where vibration prevails.
Not recommended for horizontal burning.

Sign Lighting Service

Watts	*Voltages*	*Bulb*	*Base*
10	110, 115, 120, 125	S-14 Clear	Med.
15	110, 115, 120, 125	S-14 Daylight	Med.
25	110, 115, 120, 125	A-19 Clear Daylight	Med.
50	110, 115, 120, 125	A-19 Clear Daylight	Med.

Floodlighting Service

Watts	*Voltages*	*Bulb*	*Base*
250	110, 115, 120, 125	G-30	Med.
500	110, 115, 120, 125	G-40	Mog.
500	110, 115, 120, 125	PS-40	Mog.
750	110, 115, 120, 125	PS-52	Mog.
1000	110, 115, 120, 125	PS-52	Mog.
*1000	110, 115, 120, 125	G-40	Mog.

*For use in floodlights designed to receive this lamp, where highly concentrated beam is required.

Train Lighting Service

Watts	*Voltages*	*Bulb*	*Base*
15	32, 34 or 64	A-17	Med.
25	32, 34 or 64	A-19	Med.
50	32, 34 or 64	A-21	Med.
75	32, 34 or 64	A-23	Med.
100	32, 34 or 64	A-23	Med.

Switch Indicator Service

Watts	*Voltages*	*Bulb*	*Base*	*Service*
15	30	T-6	Cand. Sc.	Westinghouse Boards
15	30	T-7	Cand. Sc.	Gen. Elec. Boards
15	70	T-6	Cand. Sc.	Westinghouse Boards
15	70	T-7	Cand. Sc.	Gen. Elec. Boards
15	140	T-6	Cand. Sc.	Westinghouse Boards
15	140	T-7	Cand. Sc.	Gen. Elec. Boards
0.11 Amp.	18	T-4	Cand. Sc.	Gen. Elec. Boards
0.11 Amp.	18	G-6	S.C. Bay Cand.	Westinghouse Boards

For use with resistance units.

Locomotive Lighting Service

Watts	*Voltages*	*Bulb*	*Base*	*Service*
15	34	S-14	Med.	Cab.
15	34	S-17	Med.	Cab.
60	32 or 34	P-25	Med.	Headlight
100	32 or 34	P-25	Med.	Headlight
250	32 or 34	P-25	Med.	Headlight

Street Lighting Service

Lumens	*Amperes*	*Bulb*	*Base*
2500	6.6	PS-35	Mog.
4000	6.6	PS-35	Mog.
6000	6.6	PS-40	Mog.

Street Railway Lighting Service

Watts	*Voltages*	*Bulb*	*Base*	*Remarks*
23	105, 110, 115, 120, 125, 130	S-17	Med.	
36	105, 110, 115, 120, 125, 130	A-21	Med.	
56	105, 110, 115, 120, 125, 130	A-21	Med.	
94	105, 110, 115, 120, 125, 130	S-24½	Med.	
23	105, 110, 115, 120, 125, 130	A-19	Med.	Headlight
36	105, 110, 115, 120, 125, 130	A-19	Med.	Headlight
56	105, 110, 115, 120, 125, 130	P-25	Med.	Headlight
94	105, 110, 115, 120, 125, 130	P-25	Med.	Headlight

The lamps listed in this Schedule are for use five in series on 525, 550, 575, 600, 625 or 650 volt circuits and should invariably be so ordered.

The following gage lamps, one and one-quarter (1¼) inches maximum overall length, are for use in series with headlights.

Amperes	*Voltages*	*Bulb*	*Base*	*Remarks*
.214	3	T-3	Min. Sc.	In series with 23 W. Headlight
.342	3	T-3	Min. Sc.	In series with 36 W. Headlight
.519	3	T-3	Min. Sc.	In series with 56 W. Headlight
.863	3	T-3	Min. Sc.	In series with 94 W. Headlight

Hand Lantern Service

Amperes	*Voltages*	*Bulb*	*Base*	*No.*	*Use*
0.15	5.00	G-4½	Min. Sc.	..	4 cell Flashlight battery
0.60	1.25	G-4½	Min. Sc.	19	1 cell battery
0.80	2.40	G-5½	Min. Sc.	35	2 cell battery

FLASHLIGHT SERVICE

Amperes	*Voltages*	*Bulb*	*Base*	*No.*	*Cells*
0.25	2.2	FE-3¾	Min. Sc.	1	2
0.27	2.3	G-3½	Min. Sc.	11	2
0.30	3.8	G-3½	Min. Sc.	13	3
0.30	2.5	G-3½	Min. Sc.	14	2
0.30	2.5	G-4½	Min. Sc.	16	2
0.30	3.8	G-4½	Min. Sc.	17	3
0.30	6.2	G-4½	Min. Sc.	31	5

MOTOR COACH LIGHTING SERVICE

C.P.	*Voltages*	*Bulb*	*Base*	*No.*	*Service*
3	6-8	G-6	D.C. Bay	64	Aux. head, tail, stop signal indicator, marker, fare box and instrument board.
3	6-8	G-6	S.C. Bay	63	
15	6-8	S-8	D.C. Bay	88	Stop, signal and step.
15	6-8	S-8	S.C. Bay	87	
21	6-8	S-10	D.C. Bay	1130	Head and Interior
21	6-8	S-10	S.C. Bay	1129	
21-21	6-8	S-10	D.C. Bay	1110*	Head
3	12-16	G-6	D.C. Bay	68	Aux. head, tail, stop signal indicator, marker, fare box and instrument board.
15	12-16	S-8	D.C. Bay	94	Stop, signal and step
21	12-16	S-10	D.C. Bay	1142	Head and interior

*Where two filament head lamps are desired on a 12-16 volt system, this lamp is recommended in series with a resistance.

SIGNAL LAMP SERVICE

Amperes	*Voltages*	*Bulb*	*Base*	*Filament*
.3	3.5	S-11	S.C. Bay Cand.	C-2
.25	8.0	S-11	S.C. Bay Cand.	C-3
.25	10.0	S-11	S.C. Bay Cand.	C-3
.25	12.0	S-11	S.C. Bay Cand.	C-3
.25	13.5	S-11	S.C. Bay Cand.	C-3

Signal lamps shall conform to A.R.A. Signal Section Plan 1544.

(2) SPECIFICATION FOR INCANDESCENT LAMPS

It was not found possible to complete this work and the subject will therefore be carried over until next year.

(3) RAILROAD YARD FLOODLIGHTING

Investigation of the subject of floodlighting as applied to railroad yards has been confined in this year's report to the general engineering features of illumination to be considered in laying out an installation and an outline of methods which experience or experimenting has indicated is representative of the best practices in the present state of the art. The problem is not susceptible of exact engineering analysis as applied to interior lighting problems. Local conditions, the general plan of the yard and other variable factors vitally affect the lighting layout that should be used, with the consequence that general recommendations may be subject to material modification when applied to a specific problem. It is therefore desirable when preparing plans for a yard floodlighting system to have assistance of those skilled or experienced in railroad floodlighting work.

Methods of Floodlighting

There are two general systems of floodlighting in use, viz.: distributed and group. In the distributed system projectors are mounted singly or in clusters of two or three at short distances through or along the sides of a yard, while in the group system they are concentrated in a relatively few locations throughout the yard. Although the distributed system possesses some advantages where heavy fog or dense smoke conditions are prevalent, the group system has become practically standard for railroad yard lighting purposes. The systems may be further sub-divided into the following methods, the selection of which are dependent upon cost, availability of space for towers, track layouts and method of yard operation.

Uni-Directional Group Lighting With Traffic.—Projectors are mounted in groups with the beams projecting in the direction in which traffic is moving. This method has the advantage of being practically free from objectionable glare. As the cars and tracks are seen by means of direct reflection of the light thrown on them, fairly high illumination intensities are required.

Uni-Directional Lighting Against Traffic.—In this system the projectors are trained against the direction of traffic with the result that objects are seen in silhouette against a bright background while specular reflection from the rails defines the tracks and rather clearly indicates the extent to which a track may be occupied by cars. Although very low illumination intensities are possible this method produces objectional glare.

Parallel Opposing Group Lighting.—Practically all modern yard floodlighting installations are a compromise of the two preceding methods in which the light may be projected either equally in both directions or a higher proportion in the direction of traffic where one-way movements exist. This system has the advantage of using direct lighting for seeing nearby objects and silhouette effect with specular reflection from the rails for distinguishing distant objects, each means inherently best for its own purpose. It also permits obtaining effective results with wide spacing of towers which in many cases will eliminate the necessity for intermediate towers between the yard tracks.

Illumination Intensities

In considering the illumination intensities a fundamental difference between yard and interior lighting must be recognized. While in the latter uniform intensity is usually secured with the preponderance of the light coming from above, in yard lighting the actual intensities will vary through a very wide range. With the exception of the immediate vicinity of a tower, the light falling on the horizontal plane is small in proportion to that thrown on the vertical plane. In the body of the yard, horizontal intensities may be of so low a value that they cannot accurately be measured with the usual illuminometer, yet at the same time the illumination produced on vertical plane is entirely adequate for purposes desired. It is therefore a difficult matter to check average intensity values from field tests.

For purposes of approximating the number of floodlighting projectors required for an installation use has been made of constants designated as *lumens per square foot,* which have been determined from experience and are based on the total flux of light in the projector beams divided by the area of the yard covered. The following values represent modern practice:

	Lumens per Sq. Ft.
Receiving and departure yards	0.04-0.1
Classification yards	0.06-0.15
Yard ladder tracks	0.1-0.3
Retarder area (yards equipped with mechanical car retarders)	0.2-0.5
Engine terminals—work areas	0.5-2.0

Experience indicates that for classification yards values of 0.08 to 0.1 will generally be adequate.

Laying Out Floodlighting Installations

Determination of Number of Lighting Projectors.—For the preliminary determination of the approximate number of projectors required a fairly close estimate may be made from the following simple calculation:

A = area of yard in square feet.
I = desired illumination in lumens per square foot.
B = beam lumens of projector selected, as obtained from manufacturers' data or laboratory test.
N = number of projectors required.

$$N = \frac{A \times I}{B}$$

Location of Towers.—Having decided upon the method of floodlighting to be used practical considerations, such as shape of the yard, track layout, method of yard operation, satisfactory available space for towers, etc., will largely determine the tower locations.

Gravity Classification Yards, Car Rider System.—Illumination is required for visibility of the ladder tracks from the hump and in the body of the yard sufficient lighting to permit the riders to control properly their cuts of cars. The need for visibility for long distances is not as essential as where the mechanical retarder system is used, but serious glare in a direct line of vision of the riders should be avoided as much as possible.

It has been general practice to locate the first tower at the hump and make use of the stray light for illumination of the hump area. The primary considerations from the lighting viewpoint in locating this tower are to project the light as nearly parallel to the yard tracks as practicable and, particularly, to direct light along the ladder tracks. Additional illumination of the hump, especially where scales are used, can be most effectively taken care of by means of local lighting.

The effective range of a modern floodlight projector having 200,000 to 300,000 beam candlepower is approximately 1200 to 2000 feet. With the opposing system of group lighting this permits tower spacing of 2400 to 4000 feet. Somewhat longer ranges are possible with floodlights producing narrow beam of high candlepower, but the area covered is small and effectiveness lost under smoky or hazy atmospheric conditions.

Gravity Classification Yards, Mechanical Retarder System.—Illumination requirements are materially different from those where the car rider system is used. The retarder operators require clear visibility of the cuts of cars as they leave the hump and as they pass through the retarders. They must also be able to distinguish the extent to which the tracks are occupied in the yard to permit properly regulating the car speeds. The number of yards equipped with this system is as yet too few and the experience in lighting them too limited to determine the best lighting practice, and further study and experimenting will be necessary before a standard method can be recommended. Experience indicates, however, that it is essential that the floodlight equipment be so located as to project light in the same directions as the operator views the various movements. To accomplish this it appears desirable to locate lighting towers immediately adjoining the retarder operator towers that control the final speed regulation in entering the yard tracks. Light should be projected towards the hump, while the retarder area should be illuminated to a relatively high intensity by short range, wide beam type of units. The units for local lighting should be so trained that the beams would not be in the direct line of vision of any of the retarder operators. To reduce costs the same tower might also mount the projectors for lighting the body of the yard.

For illumination of the distant part of the yard, units directed against traffic to produce silhouette effect will probably be found the most satisfactory method.

Flat or Engine Classification Yards.—As these yards usually involve two way switching traffic, the parallel opposing group method of lighting with equal amount of light projected in both directions will generally be found the most satisfactory method.

Mounting Height of Projectors.—Because of the more or less serious glare with the use of floodlights, high mounting heights are essential. For the usual type of projector used in railway service employing 1000-watt lamps 70 feet is recommended as the minimum mounting height, while the use of 80 or 90 foot towers may be preferable. For short range or local lighting, such as applied to car retarder areas, lower mounting heights of 40 to 60 feet may be used where the lights are directed towards the ground at relatively short distances.

Lamps for Floodlighting Service

For railway yard lighting purposes the 1000-watt PS-52 bulb general lighting service lamp is most generally employed and practically all modern types of floodlight projectors for this class of service are designed for its use. During the past year the incandescent lamp manufacturers have changed the filament construction of the standard 750 and 1000-watt PS-52 bulb lamps to adapt them better for floodlight service consistent with long life and also to make them suitable for general lighting service. Where long range is necessary requiring a narrow beam projection the 1000-watt G-40 bulb concentrated filament floodlighting lamp is recommended as standard for such service.

Selection of Floodlight Projectors

In selecting floodlight projectors for railway service the following features should be considered:

Reflectors.—Reflectors should be as efficient as practicable, consistent, however, with freedom from tarnishing and permanent deterioration due to the adverse conditions in which they will be placed. They should be so mounted in their cases that they may be readily removed if replacement becomes necessary.

Cases.—Cases should be of rugged construction, weatherproof, dusttight, of rust resisting material throughout capable of withstanding the action of gases and smoke, and with the trunnion method of mounting.

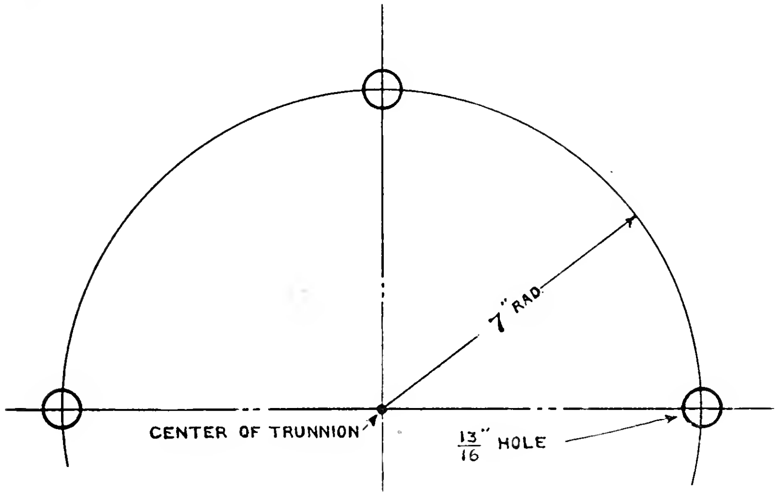


Fig. 1—Proposed Standard Spacing for Bolt Holes for Supporting Floodlight Projectors Using 750 Watt Lamps and Larger

Accessibility.—The present tendency for mounting floodlights on towers is to place them so that they are accessible from the rear. The units should be so designed that they may be readily relamped and cleaned under these conditions. Where this is accomplished by turning the unit it should preferably rotate on a horizontal axis with means provided so that it can be restored to its original position without necessity for respotting the direction of the light beam projected from the unit.

Adjustments.—Means used for focusing the lamp or training the projector should be such that necessary adjustments can be made without the aid of tools.

Supporting Base.—The advantages of interchangeable supporting bolt spacing for different makes and types of floodlight projectors used in railway yard lighting service are obvious. A study of the present bolt hole spacing for the types of units most generally used in this class of work shows that three manufacturers are now furnishing one or more of their types of projectors with the supporting bolt spacing as illustrated in Fig. 1.

Your Committee therefore recommends the adoption of this spacing as standard for floodlight projectors for railway service using 750-watt lamps or larger.

Illumination Characteristics.—Floodlight projectors have been classified in the following groups according to the characteristics of the beam:

Narrow beam, giving an angle of beam spread up to 15 degrees.
Medium beam, giving an angle of beam spread from over 15 to 30 degrees.
Wide beam, giving an angle of beam spread over 30 degrees.
Special beam, giving unsymmetrical and other special beams not included in the above three classifications.

Until recently it has been impossible to compare the relative merits of different makes and types of projectors from the illumination viewpoint as there has been no recognized standard procedure for either laboratory photometric tests or field tests. Field tests are generally unsatisfactory or unreliable for the purposes desired and expensive to make if carried out on a sufficiently comprehensive scale to produce data of value.

During the past year there has been developed a complete specification for laboratory photometric testing of floodlight projectors, adopted by the Illuminating Engineering Society and known as the I.E.S. Standard Procedure for Photometry of Incandescent Floodlights. Tests made independently by different laboratories have shown closely comparable results. The technical data obtained as result of such laboratory tests furnish complete information for comparing the relative merits of different projectors with respect to their illumination characteristics.

Factors to be Considered.—The important factors to be considered from the illumination viewpoint are:

Beam Spread (on horizontal and vertical planes).
Maximum Beam Candlepower.
Beam Efficiency or Beam Lumen Output.

The results desired in the way of light distribution for the particular application in which the unit will be used generally determines the relative value of these characteristics. For general illumination in yards the desired characteristics are a projector of medium beam classification having high beam efficiency in conjunction with high beam candlepower. Where very high beam candlepower values are used the beam approaches the characteristics of a searchlight which, while having long range, possesses but little "coverage." On the other hand a very high beam lumen output may have so low a beam candlepower value as to have insufficient range for other than purely local illumination purposes.

Definitions

The following definitions cover illumination terms more or less frequently used in connection with floodlighting engineering work:

Maximum Beam Candlepower.—As applied to floodlight projectors the maximum luminous intensity of a beam measured in candlepower, integrated over one square degree.

Beam Efficiency.—The ratio of the beam lumens or light flux of the beam to the total lumens or light flux of the bare lamp used in the projector expressed as a percentage.

Beam Lumens.—The total flux of light contained in the beam measured in lumens. Since the boundaries of the beam are usually uncertain, the edge of the beam is considered as 10 per cent of the average maximum candlepower as defined in the Illuminating Engineering Society standard specifications for testing floodlight projectors.

Beam Pattern.—The illuminated area obtained by projecting a beam of light upon a yard surface. In railway yard lighting the beam pattern is usually an ellipse, although it may be a circle, parabola, hyperbola, or a hybrid curve, depending upon the angle between the beam axis and the illuminated surface, and upon the contour of that surface. Beam pattern may also be used to designate a paper template of the beam projection for use in laying out plans of yard lighting installations.

Beam Reach.—The distance from the foot of the tower carrying the projectors to the extreme intersection of the yard surface and the beam.

Beam Spread.—The angular divergence of a beam measured in degrees. As distribution curves are usually plotted with zero degrees representing the beam axis, only half of the beam is shown. The beam spread is thus twice the angle as shown on such curves.

Beam Throw.—The distance between the light center of a projector and the illuminated yard surface, measured along the beam axis. This term is frequently confused with the term "Beam Reach."

Candlepower Distribution Curve.—As applied to floodlight projectors the candlepower distribution curve is a graphical representation of the relation of the candlepower values of a beam with the angle of divergence as measured on a plane through the axis of the beam and usually shown for the horizontal or vertical planes (see isocandle curve).

Footcandle.—The unit of illumination, with the English unit as a basis. It is defined as the illumination at a point one foot from a source omitting one candlepower in the direction of the surface. It is illumination received when one lumen of light falls on one square foot of area.

Isocandle Curve.—The isocandle curve is a plot of candlepower values on a diagram representing a sphere. For floodlighting projectors these values are measured at various points with respect to the beam axis. The lines joining all points of equal candlepower values are known as isocandle lines. The isocandle curve shows at a glance the actual spread, shape and irregularities in all planes of a beam (see candlepower distribution curve).

Lumen.—The unit of luminous flux is the amount of light (1) emitted over a given solid angle around a source or (2) received on a given area. It differs from candlepower or foot-candles in that it takes account of the extent of space or area over which the light is distributed. With reference to a source, one lumen is the amount of light emitted by a uniform source of one candlepower over a steradian, or unit solid angle. If the light source is assumed to be at the center of an imaginary sphere of one foot radius, a steradian will cover an area of one square foot on the surface of this sphere. Since such a sphere has 12.57 (4π) square feet of surface, the total light given by a source of one mean spherical candlepower is 12.57 lumens. With reference to light received on a given surface, one lumen equals one foot-candle distributed over one square foot.

Moonlight Intensity.—An intensity of about 0.025 foot-candles used frequently as a general basis of comparison in the lighting of large outdoor areas.

Mounting Height.—The height of the projectors above the level of the area to be illuminated.

Stray Light.—Light falling outside of the beam as defined under "Beam Lumens." The difference between the total lumen output of a projector and the beam lumens is the measure of the amount of stray light. Although this percentage is relatively high in floodlight projectors it represents light that is of but little value in yard lighting as due to its low candlepower value it is useful only in aiding illumination in the immediate foreground.

Remarks.—As some aspects of railroad yard lighting have important relation to the work of the Committee on Yards and Terminals, the Sub-Committee on Illumination has been in communication with the Chairman of the former about matters of mutual interest and has submitted to him a copy of the preceding report as information and for suggestions.

Conclusions

(1) That the schedules of incandescent lamps as presented in this report be accepted as recommended practice and the subject continued. It is recommended that these schedules be placed in the Manual.

(2) That the subject of the preparation of a general specification for incandescent lamps be continued.

(3) That the report on railroad floodlighting be accepted as information and the subject continued.

Appendix N

(14) DESIGN OF INDOOR AND OUTDOOR SUBSTATIONS

J. V. B. Duer, Chairman, Sub-Committee; C. L. Doub, Vice-Chairman, Sub-Committee; B. F. Bardo, J. C. Davidson, C. P. Ferguson, J. S. Hagan, C. B. Martin, P. S. Mock, H. Pattison, H. W. Pinkerton, J. E. Sharpley, J. J. Skelly, W. M. Vandersluis, L. S. Wells, R. P. Winton, Sidney Withington.

The program of work for this Sub-Committee was outlined as follows:

1. Determine conditions affecting selection of indoor and outdoor type of station.

2. Determine applicability of various methods of controlling substations and equipment as follows:

a. Manual control.
b. Remote control.
c. Supervisory control.
d. Semi-automatic control.
e. Automatic control.
f. Substation battery and charging equipment.

3. Study and report on present development and major considerations in selection of:

a. Circuit breakers—normal and high speed A.C. and D.C.
b. Air break switches.
c. Transformers—self-protecting, air-cooled, oil-cooled, oil insulated water cooled.
d. Synchronous converters, motor generators, synchronous condensers, static condensers, mercury rectifiers.
e. Protective devices:
    1. Relays.
    2. Lightning arresters.
f. Meters and meter transformers.

4. Design best fitted to obtain a maximum of safety and continuity of service during maintenance and repairs, and operation.

5. Miscellaneous important questions:

a. Tabulation of minimum clearance between conductors, and conductors to ground for various voltages, both indoor and outdoor.
b. Tabulation of adequate insulation, phase to phase and phase to ground, for various voltages, both indoor and outdoor.
c. Study of permanent and emergency grounding protections.
d. Study of possibilities in unit type of construction as applied to substations.

Three Sub-Committees were appointed to report on the subjects given in this outline.

SUB-SUB-COMMITTEE NO. 1 OF SUB-COMMITTEE NO 14

ASSIGNMENT OF DUTIES.—The work of this Sub-Sub-Committee covers two subjects: First, to determine the conditions affecting the selection of indoor or outdoor type of substation; and, second to determine the applicability of various methods of controlling substation equipment.

ACTION.—The Sub-Sub-Committee has reported previously on the first portion of their assignment. For this year they submit a report on the second portion of their assignment as follows:

Semi-automatic and full-automatic operation of D.C. substations using rotating or mercury arc converting equipment has been developed to a high state of reliability with a reduction in the cost of operation. In some cases no attendance is required other than periodic inspection and maintenance. Automatic protective features may be used to prevent improper operation or to shut down apparatus in case of trouble.

Full-automatic substations which are started and stopped by load responsive control requiring no attendant may be used where substations are located far apart and loaded only at infrequent intervals and where no attendance would otherwise be required as, for example, interurban lines.

Semi-automatic substations may be used where substations are large or close together and where load demands are frequent. The starting or stopping of these substations may be initiated by an operator in the substation or by a power supervisor by means of remote control in advance of anticipated load. In trunk line railway service semi-automatic control has become general practice to prevent excessive starting and stopping of the equipment during short intervals between peaks with resultant heavy maintenance of relays and equipment and possible delays to service.

Many features of semi-automatic and full-automatic operation are similar and will be described under "sequence of Operation" and "Protection." The principal difference in the two types consists in the method by which the impulse for starting and stopping the apparatus is initiated.

SEMI-AUTOMATIC OPERATION.—The initial impulse for starting or stopping a machine may be controlled in either of the following ways:

1. The operator in the substation may perform any or all the operations to start or stop the machine and thereafter the operation and protection are automatic, or the operator may merely throw a double throw start-stop switch which automatically starts the machine and connects it to the line. In case the machine shuts down due to abnormal conditions it automatically starts again as soon as conditions become normal, provided the shutdown was not occasioned by some defect in the apparatus which renders it inoperative. Machines are taken out of service by throwing the control switch to the "stop" position.

2. The machine may be started or stopped from a distant point by means of remote control. Where the length of control circuit is not great and speed of operation is essential, separate control wires may be provided for each piece of apparatus. Where distances are great, some form of

supervisory control requiring not more than four wires may be more economical.

Full-Automatic Operation.—For full-automatic operation the initial starting impulse is given by an undervoltage relay connected to the D.C. line and set for some predetermined value less than normal voltage. If the substation has more than one machine, succeeding machines may be started by thermal relays on the machine first started. The machines are automatically shut down by time delay underload relays so that unless the load falls off for a period of more than setting of the timing relay the machines will not shut down. This feature prevents unnecessary stopping and starting of the machine for short periods of light loads.

Sequence of Operation.—The sequence of operation for starting rotary converters is usually as follows. The operation may be manual or automatic:

1. Close high tension oil breaker.
2. Close starting switch on low voltage connection.
3. After converter is up to synchronous speed and polarity is correct close field switch. In case polarity is incorrect it can be reversed by the field switch.
4. Open starting switch and close running switch.
5. Lower brushes on commutator.
6. Close negative breakers.
7. If the bus voltage is lower than the machine voltage the converter is connected to the bus load limiting resistance.
8. If the load supplied by the converter is less than the setting of the load limiting relays the resistors are short circuited and the machine is in normal operating condition.

Protection

(A) *Starting.*—Before equipment starts automatically the following conditions must exist:

1. Temperature of the winding must be normal.
2. Temperature of resistor must be normal.
3. Temperature of bearings must be normal.
4. Lock out circuit must be normal.
5. Positive breaker must be closed.
6. A.C. voltage must be normal.
7. Brushes must be raised.

The machine is protected during starting against the following:

a. Low A.C. voltage. Machine will not start until A.C. voltage is normal. If low voltage occurs during the starting, the machine will shut down until voltage is normal.
b. Phase failure. If phase conditions are not normal the machine will not start. If phases are unbalanced during starting, the machine will shut down and lock out.
c. Abnormal starting time. If the starting sequence is not completed within the setting of the starting timer, the machine is shut down and locked out.

(B) *Running.*—The machine may be protected, while running, against the following:

1. Severe A.C. overland. Time delay overload relays shut down and lock out the machine.
2. D.C. overload. On moderate overload, load limiting resistors are connected in series with the machine until the overload is removed. On severe D.C. short circuit, the high speed breaker opens and the machine idles until the overload is removed.
3. Shunt field failure, D.C. breakers open and the machine is shut down and locked out.
4. Overspeed. If the machine runs more than 15 per cent. overspeed, the overspeed device will shut down the machine.
5. Ground on the machine or flashover to ground. Relay shuts down and locks out machine.
6. Low A.C. voltage. Machine shuts down until voltage is normal.
7. Overheated windings. Machine shuts down until temperature is normal.
8. Overheated bearings. Machine shuts down and is locked out.
9. Overheated load limiting resistors. Machine is shut down until resistors are cool.
10. Reverse power. Moderate reverse power will open positive breaker. Heavy reverse power will shut down and lock out the machine.

When the machine is shut down and locked out due to defect in apparatus, the lock out relay must be reset by hand before the machine can be started again.

(C) Feeder breakers may be of the short-circuit detector automatic reclosing type which will reclose after opening on an overload, provided the resistance of the load is above a predetermined value.

Substation Battery Charging Equipment.—There are three general types of equipment in use for charging substation batteries. These are as follows:

1. Motor-generator sets.
2. Hot cathode and mercury arc rectifiers.
3. Copper oxide rectifier.

Motor-generator sets are preferable where rather heavy demands are made up on the battery and it is necessary to charge the battery quickly to provide for further possible demands. A motor-generator set can be secured to furnish any rate of current to the battery and makes possible the maximum advisable rate of charge, so that the time required to restore a discharged battery to full charge is a minimum.

Hot cathode or mercury arc rectifiers are preferable where the amount of charging required is small and is within the capacity of the rectifier.

A new type of copper oxide rectifier has been perfected which is now available in capacities up to 3 amps. at 120 volts, and larger units will be available in the near future.

With any type of charging equipment, automatic control of the charging is desirable. This is accomplished with a motor-generator set by the utilization of ampere-hour meter control. The ampere-hour meter measures the ampere-hours supplied to and discharged from the battery. It is provided with electrical contacts which cut off the charge when the meter indicates the certain degree of discharge for which the meter has been set. Where the battery set remains idle for periods, the ampere-hour meter should be equipped with a thermo couple which will allow a low discharge current to be recorded to compensate for loss of battery capacity caused by the battery being idle.

With the hot cathode or mercury arc rectifier, the charging is, as a rule, automatic by nature. The rectifier is selected of such capacity that it delivers only a small percentage of the normal charge rate to the battery and it operates continuously, furnishing current at the low or trickle charge rate. This trickle charge rate must be of sufficient amount to maintain the battery properly against all normal demands. "Trickle" charging is not recommended for nickel-iron alkali batteries, due to the voltage characteristics of the type of battery.

When using a motor-generator for charging, two general types of charge control are used. These are:

1. Constant current regulation.
2. Modified constant voltage regulation.

The constant current type of regulation may be used for any type of battery, but due to the voltage characteristics of nickel-iron-alkali batteries, this system of charging is preferable for them. For this system of regulation, an automatic regulator must be used to hold the charge rate constant to a predetermined amount throughout the charge. When the battery becomes fully charged, the charging is stopped by the operation of the ampere-hour meter control. With this system, in order to minimize gassing, the charge rate must be lower than the average charge rate permissable when using the modified constant potential system and, consequently, it will take longer to recharge the battery. The full capacity of the charging equipment, however, can be used throughout the charge and, consequently, equipment of smaller capacity may sometimes be used.

The modified constant potential type of regulation is preferable for lead batteries. For this system of regulation, a charging generator with a drooping voltage characteristic is best. The battery can be charged at a high rate at the beginning of the charge and as the voltage of a battery rises rapidly toward the end of the charge, the drooping characteristic of the generator will taper off the charge automatically to prevent excessive gassing. This system facilitates the most rapid and efficient restoration of a discharged battery.

Although the above two types of charging equipment are the most usual and generally preferable, there are other systems which at times may be advantageous. A general listing of possible arrangement follows:

(A) Constant voltage D.C. source available.
  (1) Use existing D.C. source if voltage is proper.
  (2) If voltage is not suitable, reduce to suitable voltage by:
    a. Counter e.m.f. cells.
    b. Motor-generator set.
    c. Resistance units.

(B) A.C. source of power.
  (1) Change A.C. to D.C. at proper voltage by:
    a. Motor-generator sets.
    b. Hot cathode rectifiers.
    c. Mercury arc rectifiers.
    d. Rotary converters.
    e. Copper oxide rectifiers.

The charging panel for each charging circuit should include:

1. Overload protection.
2. Provision for reading charging current.
3. Provision for reading charging voltage.
4. Necessary switches.

In view of the foregoing, it is the recommendation of the Sub-Committee that the following types of battery charging equipment be adapted for the different installations. The question of battery capacity, together with the capacity of the charging equipment and rates of charging current to the battery, however, should be given careful consideration in each case to most favorably meet the service for which the equipment is to be used.

For installations where A.C. and D.C. is available and where the current demands on the battery are large, as oil switch operation, emergency lighting, etc.:

Lead acid battery—Motor-generator set with suitable control equipment for full automatic operation with modified constant voltage regulation.

Nickel-iron battery—Motor-generator set with suitable control equipment for full automatic operation with constant current regulation.

For installations where A.C. is available and where the current demands on the battery are small:

Lead acid battery—Hot cathode rectifier or mercury arc rectifier to provide for continuous low or trickle charge rate of current to the battery.

Nickel-iron battery—Motor-generator set with suitable control equipment for full automatic operation with constant current regulation.

For installations where D.C. is available and where the current demands on the battery are small:

Lead-acid battery—Motor-generator set with suitable control equipment for full automatic operation with modified constant voltage regulation.

Nickel-iron battery—Motor-generator set with suitable control equipment for full automatic operation with constant current regulation.

SUB-SUB-COMMITTEE NO. 2 OF SUB-COMMITTEE NO. 14

Assignment of Duties.—Study and report on the present development and major considerations in the selection of circuit breakers, air break switches, transformers, synchronous converters, motor generators, synchronous condensers, static condensers, mercury arc rectifiers, relays, lightning arresters, meters and meter transformers.

Action.—The Sub-Sub-Committee has made a further study of the use of mercury arc rectifiers and also that portion of their assignment not covered in their previous report. They submit a report on these items as follows:

Mercury Arc Rectifiers

Due to recent development on the mercury arc rectifiers, as well as the low cost of building for housing this type of equipment, installations of the 650-volt class have shown a saving in first cost over rotating machinery of similar capacity. Installations of rectifiers of high voltage ratings are also showing further economies compared to some of the older installations.

The mercury arc rectifier presents the attractiveness of having no main moving parts, thereby eliminating most of the troubles which are encountered in the operation of rotating machinery. It is thus particularly fitted for automatic or remote control installations. On the other hand, the rectifier requires certain auxiliary equipment which may lead to trouble. More extensive experience with rectifiers is needed to determine this condition definitely. Also for roads having heavy grades where regenerative braking is desirable, rectifiers cannot be used exclusively since they cannot return regenerated D.C. power back into the A.C. system.

Similar to the rotary converter, the D.C. voltage of the mercury arc rectifier bears a constant ratio to the alternating current voltage. In the case of a rectifier, the D.C. voltage is fixed by the A.C. voltage applied to it, while for a rotary converter, the D.C. voltage may be varied within certain limits by changing the field strength. The power factor of the rectifier is also fixed, being approximately 92 per cent for loads above 25 per cent of full load capacity, while the power factor of the converter may be also varied by change of field strength. The overall efficiency of the rectifier with its step-down transformer is materially greater than that of the rotary converter, particularly at light loads. On a fluctuating traction load with its heavy momentary peaks and an average output of 50 to 60 per cent of the rated capacity, the rectifier has an efficiency of from 5 to 7.5 per cent higher than the converter. This higher efficiency of the rectifier, over the converter, for loads slightly better than 100 per cent points to their selection even for 600-volt service. Above 600 volts the reason for their use is still greater since the rectifier losses are practically independent of the output voltage.

Operating experience obtained with 600-volt and 1500-volt rectifiers, in both manually and automatically controlled substations, indicates a rapid extension of their use. The possibilities for higher voltages are still greater, and some now are being offered at 3000 volts.

The susceptibility of rectifiers to internal shorts or "arc-backs" may be considered equivalent to, but not greater than, the commutating difficulties experienced with rotating machinery.

Inductive influences on neighboring communication circuits from rectifiers possessing no means of limiting the harmonic component is greater than with rotating apparatus. Experience has shown, however, that by means of properly designed filtering apparatus on the direct current load side of the rectifiers, the inductive influence may be reduced to a level comparable with that of a properly designed rotating machine.

Protective Devices

Relays

One of the most important items of the protective equipment is the protective relay. Relays should, therefore, be accurate, sensitive and rugged. The importance of the circuits to be protected determines the extent of care with which the selection of the relay should be made with regard to the above characteristics.

In the electrical systems which supply power for the movement of trains, it is very important that, upon the occurrence of trouble on a portion of the system causing the automatic opening of circuit breakers, the interruption of power be confined to the faulty section and not affect the main supply to the point of distribution. This can be accomplished by careful selection, intelligent arrangement and proper settings of the relays.

A function of protective relays, other than line or circuit protection, is equipment protection. With the present large loads, the conversion equipment is necessarily large and accordingly high in cost. Therefore, stress should be placed upon such selection of relays for equipment protection that upon either internal or external faults affecting the safety of the equipment, extensive damage may be avoided by quickly and properly disconnecting this equipment from the system.

In circuit or equipment protection the application of relays is very closely associated with the circuit breakers which are installed to sectionalize the circuit, since the relay is the instrument which selects the circuit opening device required to operate in order to relieve the system of the abnormal condition. Current transformers and potential transformers are connected to the circuit and these combined with properly connected relays, determine very accurately the condition of the circuit. Abnormal conditions tend to close or open a circuit controlling the circuit-disconnecting device which will cause the desired functioning of this sectionalizing apparatus. The source of power supply to the control circuit between relay and the switch or device which it operates should never be taken from the circuit which it controls since the condition of the protected circuit at time of fault may be such that the desired results would not be obtained. It is recommended that a constant and independent source of power, such as a storage battery, be used to supply the circuit between the relay contacts and the sectionalizing device.

If the operation of the station is such that there is a certain sequence of operation required for the connecting of power equipment to the system and if a sequence of operation or an arrangement of circuits other than that required would cause damage to the equipment, relays should be provided which will either prohibit the misoperation or automatically open the power supply to the equipment quickly in order to prevent possible damage to the machine or apparatus.

There are numerous relays on the market today and it is possible to secure relays for the proper protection of the circuit, no matter what the function, characteristics or connections may be. The following are functions which it is desirable to have relays perform in the protection of lines and substation apparatus, some of which may be performed by the same types of relays:

1. Disconnect alternating current apparatus when over-current condition occurs.
2. Disconnect alternating current apparatus when over-voltage or under-voltage occurs.
3. Disconnect fault, either small or excessive, causing power flow in reverse direction.
4. Protect windings of A.C. or D.C. apparatus when over-heating occurs.
5. Prevent starting of synchronous converters when voltage is low.
6. Insure the proper timing of motor-started converters when pulling into step.
7. Insure correct polarity on D.C. end of converters.
8. Prevent inverted operation of converters.
9. Disconnect converter from line when commutator flashes over.
10. Disconnect transformer from line when internal fault occurs.
11. Disconnect line when over-current occurs.
12. Disconnect faulty section of line when short circuit occurs.
13. Disconnect grounded sections of lines or individual pieces of apparatus.
14. Prevent holding circuit breakers in on grounds or short circuit.

Relays for direct current are usually of the pivoted armature type or solenoid and plunger type. These relays can also be used on alternating current if the iron core is laminated. Induction type relays similar in operation to the induction type watt-hour meter can be used on alternating current only. These relays consist of an aluminum disc or vane in the air gap of a field magnet having windings connected to the circuit to be protected. These windings may be connected in series with the load for over-current protection, across the line for over-voltage protection or in a combination of the two for over-power protection. The magnetic field produced by the windings induces currents in the disc which react with the magnetic field causing the disc to rotate thereby closing the tripping circuit. The disc also rotates in the air gap of a permanent magnet which can be adjusted to give a time delay. The induction type relay is much more accurate than the solenoid type.

Current relays may be divided into three classes with reference to the time element:

1. Instantaneous.
2. Definite time limit.
3. Inverse time limit.

So-called "instantaneous" relays operate in a fraction of a second regardless of the overload. Definite time limit relays operate in a definite time according to the setting regardless of the overload. Inverse time limit relays operate in a time inversely proportional to the amount of the overload. In case of a very heavy short circuit, these relays operate in a very short time, but on a small overload the operation is delayed to take care of small overloads of short duration and to give selective operation to the various circuit breakers feeding into the fault.

The time element of solenoid relays usually consists of air bellows or oil dash pots.

Overload relays have their windings in series with the load or a current transformer giving a current proportional to the load.

Over or under voltage relays have their windings connected across the line or a potental transformer giving a voltage proportional to the line voltage.

Power relays have one coil in series with the load and the other winding across the line. These relays can be used to trip circuits on reverse power.

Differential relays have two sets of windings acting in opposition on the same moving element. These relays can be used on two parallel feeders which under normal conditions will have equal loads. In case of a fault in one feeder the torque produced by the two windings becomes unbalanced and the relay operates so as to disconnect the faulty feeder.

Lightning Arresters

The insulation of apparatus connected to electric systems is subject not only to the stresses prevailing under normal conditions but also to transient stresses caused by atmospheric or system disturbances. These transient stresses are variable but often of sufficient intensity to injure or even puncture the insulation of apparatus.

Atmospheric disturbances arise from the gradual accumulation of charges in clouds and their subsequent discharge. Charges are impressed on the system in various ways, the most important of which are direct strokes and release of bound charges.

System disturbances consist either in the discharge into the system of the energy of magnetic fields of apparatus at the time of switching or in the readjustment required when some capacitance is connected to the system. System faults also cause surges which may be dangerous.

In either case the energy involved is comparatively low, if the duration of the disturbance is comparatively short but the voltage may be high and the power flow, since it is limited only by circuit impedence, may also be high.

Direct strokes of lightning from clouds to the electrical system produce such high rates of flow of power that the equipment may be damaged regardless of any protection so far built. While this sort of disturbance is within the sphere of the lightning arrester application, no device has yet been made which will afford complete protection.

The lightning arrester provides protection for the insulation of apparatus against damage due to those transient stresses by holding them at a value within the range of voltage for which the equipment is designed. Dangerous surges are characterized by a high voltage and a steep wave front. An arrester may act in response to an increase in voltage or to an increase in rate of change of voltage.

The value of an arrester as a means of protection depends on the extent to which surge voltages are prevented from rising. For good performance it is necessary that the voltage at which the arrester functions is safe for the insulation to be protected, and also that the impedence to flow of surge current be low in comparison to the surge impedence of the circuit to which it is connected. In addition the arrester should not cause line disturbances by an excess flow of current due to line voltage.

Whether a lightning arrester should be installed at a given point will depend on the value of the protection desired. The factors to be considered are the prevalence of lightning discharges in that locality, the value of the apparatus to be protected and the cost of interruptions to service.

When lightning arresters are installed, their intent is to reduce the amount of the transient stress by discharging a part of it to ground. Part of the transient, reduced somewhat by choke coils which are placed between arrester and the apparatus to be protected, will reach the apparatus. The efficiency of the arrester will depend largely upon the type used and whether properly installed and maintained.

Since the cost of arresters and the maintenance is high in many cases, it is desirable to reduce their number to a minimum. Thus where a line passes through a substation bus, protection to the apparatus may be afforded by lightning arrester protection on the bus instead of on the lines where they come in and where they go out. However, where two or more lines have taps to one bus, protection on each incoming line is necessary to prevent a transient voltage from affecting all lines.

In the application of lightning arresters, it is essential that their connection to ground be of as low resistance as is possible. Since it is the total impedence to flow of surge current which controls protection, the best arrester cannot act efficiently without a good ground connection.

Meters, Instruments and Instrument Transformers

Instrument transformers are of two kinds—potential and current. The potential transformer is used to insulate instruments and meters from high potentials and to change the voltage to a safe and convenient value within the range of the meters or other apparatus. The current transformers are used to insulate instruments and meters from high potentials and to change the current into a safe and convenient value within the range of the connected instruments.

Both types of transformers depend on the integrity of insulation for their successful operation and when used on high potentials it is essential that the insulation be designed and maintained with sufficient factor of safety to eliminate danger of breakdown which might allow high voltage to enter switchboard circuits with consequent danger and hazard to life and operation.

Potential transformers are usually protected by fuses and also by current limiting resistances in the primary leads, the intent being to effectively limit the flow of current in the event of a failure in the transformer when used on high potentials. They are usually placed in cells or compartments to insulate any trouble which may develop.

It is essential that potential transformers be accurate if they are to be used with meters. This is especially true of watt-hour meters, where errors are cumulative. For this reason watt-hour meters are usually calibrated with the associated transformer.

Current transformers are of various types, depending upon the use for which they are designed, and their location. The degree of accuracy of transformation desired has a large influence as to type to be used. When integrating watt-hour meters are used the combined load or ampere burden of all the instruments in the circuit should not exceed the rated capacity of the current transformer. In some cases it is desirable to use separate current transformers for integrating watt-hour meters.

It is essential that the secondary circuit for current transformers never be left open in service; otherwise a dangerous voltage will be induced.

There are various kinds of instruments in use for railroad electrical work, most of which, in the case of alternating current power measurements are associated with series or potential transformers for their operation.

Voltmeters, as their name implies, are used to measure the voltage of an electric circuit. The voltage to be measured is reduced if necessary by means of a potential transformer in the case of alternating current or by resistance in the case of direct current. The voltmeter is an instrument connected across the circuit to be measured, and by means of a high resistance coil arrangement—so that the actual current flowing through it is very small—properly calibrated, the voltage is read directly upon a scale. If desired, the apparatus may be arranged to record the voltage graphically, the record paper being made to move under a pen point, usually by means of clockwork.

Ammeters are series instruments used to measure the quantity of current flowing in a circuit. In measuring relatively small currents the meter may be so arranged that the entire current passes through it, but if the amount of current to be measured is large the meter is so arranged that the current which it measures bears a definite and known ratio to the total current flowing. This is accomplished in the case of alternating current by a series or current transformer, above described, and in the case of direct current by a so-called shunt or low resistance in parallel with the main circuit. With the meter so connected, it measures the small voltage drop across the shunt, which drop is definitely proportional to the main flow of current. The readings—either indicating or recording—usually show the total current. It is obvious that ammeter coils are of a relatively low resistance; and that is the fundamental difference in construction between the ammeter and the voltmeter.

The WATTMETER as its name implies, measures watts or power. Since power is a function of the product of volts and amperes, it is obvious that the wattmeter should measure both and automatically combine the measurements which may be qualified, however, as indicated below. There are the current coils and voltage coils, connected through suitable current and voltage transformers, or resistances and shunts, for alternating current and direct current circuits, respectively. The wattmeter may be indicating or recording just as are the voltmeter and ammeter, or it may automatically integrate or summate the watts on the basis of time, in which event it is called a watt-hour meter; and the watts times hours, or watt-hours, are read on dials numerically.

A further application of the wattmeter is in integrating or averaging the power demand over any predetermined period, in which case it is called a *demand meter.* The demand may be measured as an instantaneous demand, or as an average integrated demand over a period of any duration from a few seconds to an hour. This application is extremely important in power contracts.

The principle of design of the integrating watt-hour meter is somewhat different from that of the recording wattmeter. In the latter case, the deflection of a needle by means of properly arranged coils provides the indication, and a moving record paper under the needle permits the drawing of the graph. In the former case, however, the meter is in the form of a motor which varies in speed proportionately to the product of volts and amperes (qualified as indicated below) and which is geared suitably to the indicating dials.

In the case of alternating current watt-hour meters, the power is the product not only of the volts and amperes, but of the added factor of the cosine of the angle by which the current lags behind or leads the voltage, or the power factor. It is essential that the useful current only be measured and that the wattless or lagging current be eliminated. This is accomplished by properly locating the voltage and current coils in the meter with respect to each other.

This question of power factor is sometimes of importance, and there have been devised meters to measure it directly or indirectly. The current which does not represent useful power is known as wattless or reactive current, and although it does not represent power, it nevertheless does act to heat the conductors and apparatus just as does the useful current. The meters to measure this characteristic are known as reactive volt-ammeters. As the name implies, they measure the product of volts and wattless current. The principle is the same as that of wattmeters, but the relative positions of the coils are such that only wattless current is effective.

It is obvious that if the power factor or cosine of the angle of lag of current is desired, it may be obtained by three meters—a voltmeter, an ammeter and a wattmeter. The ratio of the watts to the product of the volts and amperes would give the power factor, which is usually expressed in per cent. Another method would be by means of wattmeters and reactive volt-ammeters. There are power factor meters available which indicate or record directly the power factor in per cent. These normally operate with current and voltage coils acting upon an indicating needle as in the wattmeter, except that two voltage coils are so connected in parallel, the current in one flowing through reactance and in the other through resistance, that normally there is a fixed phase relation as to the current flowing through them. Change in power factor or phase relation on the main circuit are thus indicated by proper calibration of the needle indications.

Meters for use on polyphase systems are similar in principle to those in single phase alternating circuits, but usually with the addition of current coils to summate the readings. Two current coils for a three-phase circuit are usually sufficient, since the return for any conductor in a balanced three-phase metallic circuit is always through the other two .equally.

A type of instrument which is in common use on alternating current power circuits is the frequency meter. This may be either indicating or recording. These meters show the frequency in cycles per second. They are connected to high potential systems through potential transformers. In general, frequency meters are of two rather radically different types; first, vibrating reed or resonant type, dependent on the resonance of a vibrating steel reed the natural period of which is known. Impulses are given by means of an electro magnet to a series of such reeds, each with a different natural period. Only that reed which vibrates in synchronism with the system will move. The other types are based upon the principle that the current flowing in a circuit varies with the reactance. Two circuits are in parallel, one non-reactive, the other of high impedence. The amount of current flowing in the non-reactive circuit does not vary with the frequency, while that in the other does. The relative amount of current flowing in the two circuits thus is an index of the frequency and may be indicated or recorded through proper calibration.

Direct Current Instruments.—For the commercial measurement of direct current and voltage, the *permanent magnet, moving coil* instrument is the standard type. This consists of a light coil free to turn in field of a fixed permanent magnet. The deflection is proportional to the current flowing, and the instrument is always an ammeter, but may be used either as a voltmeter or to measure current. When used as a voltmeter the coil is composed of many turns of fine wire and a resistance coil of a comparatively high resistance is connected in series with it. When high currents are to be measured a large portion of the current is diverted through a suitable "shunt," the current through the coil being small but in proportion to the total current flowing through the shunt.

Instruments for Use on Both Direct and Alternating Current.—Such instruments may be divided into four types, namely, electro-dynamometer, electromagnetic, hot wire and electrostatic.

Electro-dynamometer instruments depend upon the force exerted by one circuit (traversed by a current) upon another, or by a portion of a given circuit upon another portion of the same circuit. They have two coils connected in series, which are so connected that the torque exerted upon the moving system is proportional to the square of the current strength, and is not dependent upon the direction of the current. This instrument may be calibrated as a direct current instrument and used with accuracy to measure alternating current. Electro-dynamometer voltmeters and wattmeters are of an arrangement similar to the ammeter except that the fixed and moving coils are varied as to size of wire and the addition of resistance to meet the requirements.

Electromagnetic instruments depend upon the action of a coil (traversed by a current) upon one or more pieces of iron. These instruments are also known as "moving iron," "soft iron" and "iron vane" type: Ammeters and voltmeters of this type are well suited for commercial measurements on alternating current circuits and for direct current when only approximate results, within 2 or 3 per cent are required. These instruments may be checked accurately on direct currents.

The hot wire type depends upon the expansion of a wire which is heated by the passage of a current. In the voltmeter this wire is very fine and a series resistance is provided. In the ammeter the working wire is larger and is connected with several sections in parallel to reduce the required drop in the shunt.

Electrostatic instruments depend upon the attraction of oppositely charged bodies and the repulsion of similarly charged ones. Since these forces are relatively small, such instruments cannot be well made as ammeters, and in fact it is difficult to construct a voltmeter on this principle for the ordinary 110-volt range. The great advantage of this type of voltmeter is that it takes no current when used on direct current circuits and an extremely small current when used on alternating current circuits.

Alternating Current Instruments.—Instruments operating only on alternating current depend upon the interaction of inducing and induced currents, and are usually described as induction instruments. The usual form contains a laminated iron core surrounded by one or more coils of wire; an alternating magnetic flux is set up in the air gap of this core when current flows through the coils. Meters of this class vary greatly with change in frequency.

The induction watt-hour meter has the great advantage of absence of a commutator and brushes. It also has a very light moving element.

Induction instruments are not suitable for general service in the laboratory.

SUB-SUB-COMMITTEE NO. 3 OF SUB-COMMITTEE NO. 14

Assignment of Duties.—1. Study and report on substation design best fitted to obtain a maximum of safety and continuity of service during maintenance, repairs and operation.

2. Compile tabulation of minimum clearances between conductors, and between conductors to ground for various voltages, both indoor and outdoor.

3. Compile tabulation of adequate insulation, phase to phase and phase to ground, for various voltages, indoor and outdoor.

4. Study and report on permanent and emergency grounding practices.

5. Study and report on possibilities of unit type of construction as applied to substations.

Action.—Item No. 1 of the assignment for the Sub-Sub-Committee was covered in report of 1926.

Items No. 2 and 3 were covered by a questionnaire to railroads and power companies, and the Sub-Committee submits for this year's report the information received.

A brief questionnaire was sent out in January, 1928, to 50 power companies and 37 railroads covering substation design elements as follows:

1. Operating voltage KV.
2. No. of phases.
3. Frequency—cycles.
4. Indoor or outdoor.
5. Bus supporting structure:
   (a) Masonry.
   (b) Steel pipe.
   (c) Structural steel unit type.
6. Clearance—inches:
   (a) Phase to phase.
   (b) Phase to ground.
7. Insulation. flashover value—KV:
   (a) Phase to phase.
   (b) Phase to ground.
8. Is system neutral grounded?
9. Remarks.

Replies were received from 21 power companies and 28 railroads, and these were analyzed in detail to show for indoor and outdoor stations, respectively, the phase-to-phase and phase-to-ground clearances as a function of the bus or substation voltage. The method used involved plotting clearance in inches against voltage. Due to the general use of more or less commercial voltages such as 2200, 4400, 6600, etc., this resulted in a number of groups of points through the averages of which a straight line was drawn.

In Tables 1, 2, 3 and 4 the minimum and maximum values for clearance were taken directly from the questionnaire. The average value was calculated for the many clearances reported for each given voltage. The curve value was taken for each voltage range from the straight line characteristic drawn with the average of each group as a guide.

It will be apparent that the so-called curve will yield a value of clearance for each voltage which will not agree with the average but which will be, for any given voltage, between the minimum and maximum. It is also to be noted that the clearances, for voltage other than usual commercial standards, must be obtained by recourse to some sort of line or curve as above described. The variations between minimum and maximum are quite wide and this is a reflection of at least two tendencies:

(a) Raising voltage some years after design was developed.
(b) Providing ample clearance to permit of raising the voltage ultimately, although operating for the present at a low value.

Table 1 covers indoor substations, phase-to-phase clearance.
Table 2 covers indoor substations, phase-to-ground clearance.
Table 3 covers outdoor substations, phase-to-phase clearance.
Table 4 covers outdoor substations, phase-to-ground clearance.

Further analysis of the reported data showed the following:

(a) Phases and Frequencies: *Per Cent*

3-phase, 60-cycle	72.8
3-phase, 50-cycle	5.2
3-phase, 25-cycle	12.6
2-phase, 60-cycle	4.2
1-phase, 25-cycle	5.2

(b) Indoor or Outdoor Design:

Indoor	51.4
Outdoor	48.6

(c) Bus Supporting Structure:

Masonry	29.5
Steel pipe	22.8
Structural steel	45.7
Steel truck type	2.0

(d) Neutral:

Ungrounded	29.1
Grounded	58.2
Grounded with resistance	12.7

(e) Flashover Values

Dry, varying from 4.2 to 14 times working voltage.
Wet, varying from 2 to 5 times working voltage.

Table No. 1—Indoor Substations

Clearance Phase-to-Phase—Inches

Note.—Based upon values reported for forty-two substations, of which sixteen were of railroads.

	Clearance			
Kilovolt Range	*Minimum*	*Maximum*	*Average*	*Curve**
2-3	6.0	24.0	13.0	9.3
3-4	...	...	...	10.5
4-5	4.0	16.0	10.5	11.0
5-6	...	...	...	11.6
6-7	8.0	16.0	12.0	12.0
7-8	...	...	...	12.9
8-9	...	...	...	13.5
9-10	...	...	...	14.0
10-11	12.0	36.0	15.4	14.7
11-12	13.0	18.0	15.5	15.2
12-13	...	...	...	15.8
13-14	12.0	19.0	15.5	16.5
14-15	...	...	...	17.0
15-20	...	...	...	19.0
20-25	14.0	29.5	20.5	23.0

*Straight line characteristic, value being for higher figure in kilovolt range, i. e., range 2-3, 9.3 is for 3-KV.

Table No. 2—Indoor Substations

Clearance Phase-to-Ground—Inches

Note.—Based upon values reported for thirty-eight substations, of which sixteen were of railroads.

Kilovolt Range	Clearance *Minimum*	*Maximum*	*Average*	*Curve**
2-3	3.5	10.0	6.6	5.0
3-4	...	...	...	5.5
4-5	2.5	8.0	5.6	5.9
5-6	...	...	...	6.3
6-7	6.0	14.0	9.0	6.8
7-8	...	...	...	7.2
8-9	...	...	...	7.7
9-10	...	...	...	8.2
10-11	8.0	18.0	12.8	8.6
11-12	6.0	8.0	7.0	9.0
12-13	...	...	...	9.5
13-14	3.5	14.0	7.0	10.0
14-15	...	...	...	10.4
15-20	...	...	...	12.7
20-25	...	...	...	15.0

*Straight line characteristic, value being for higher figure in kilovolt range, i. e., range 2-3, 5 inches is for 3-KV.

Table No. 3—Outdoor Substations

Clearance Phase-to-Ground—Inches

Note.—Based upon values reported for thirty-five substations, of which seven were of railroads.

Kilovolt Range	Clearance *Minimum*	*Maximum*	*Average*	*Curve**
0-5	6.0	14.0	9.0	8.0
5-10	...	...	...	11.0
10-15	6.3	30.0	13.0	12.5
15-20	...	...	...	14.5
20-25	18.0	29.5	23.8	16.5
25-30	15.0	18.0	16.5	18.5
30-35	15.0	36.0	17.0	21.0
35-40	...	...	...	23.0
40-45	11.0	21.0	20.0	25.0
45-50	...	...	...	27.0
50-60	30.0	32.0	31.0	31.0
60-70	19.0	56.0	34.0	35.0
70-80	...	...	...	39.0
80-90	...	...	...	43.0
90-100	...	...	...	47.0
100-110	40.0	48.0	43.0	51.5
110-120	...	...	...	56.0
120-130	...	...	...	59.5
130-140	60.0	71.0	65.5	63.5
140-150	...	...	...	67.5
150-160	...	...	...	72.0
160-170	...	...	...	76.0
170-180	...	...	...	80.0
180-190	...	...	...	84.0
190-200	...	...	...	88.0
200-210	...	...	...	92.0
210-220	78.0	78.0	78.0	96.5

*Straight line characteristic, value being for higher figure in kilovolt range, i. e., range 0-5, 8.0 is for 5-KV.

Table No. 4—Outdoor Substations

Clearance Phase-to-Phase—Inches

Note.—Based upon values reported for thirty-four substations, of which twelve were of railroads.

Kilovolt Range	Clearance Minimum	Maximum	Average	Curve*
0-5	8.0	36.0	20.5	16.0
5-10	...	...	...	20.0
10-15	6.0	72.0	25.0	24.0
15-20	...	...	...	28.0
20-25	...	...	...	32.5
25-30	30.0	36.0	34.0	36.5
30-35	19.0	48.0	35.0	40.5
35-40	...	...	...	44.5
40-45	33.0	72.0	47.0	48.5
45-50	...	...	...	53.0
50-55	...	...	...	57.0
55-60	60.0	72.0	66.0	61.5
60-70	32.0	96.0	64.0	70.0
70-80	...	...	...	78.0
80-90	72.0	96.0	84.0	87.0
90-100	...	...	...	95.0
100-110	82.0	120.0	101.0	103.0
110-120	...	...	...	109.0
120-130	...	...	...	118.0
130-140	96.0	160.0	128.0	127.5
140-150	...	...	...	136.0
150-160	...	...	...	144.0
160-170	...	...	...	153.0
170-180	...	...	...	161.0
180-190	...	...	...	169.0
190-200	...	...	...	177.5
200-210	...	...	...	186.0
210-220	...	...	...	195.0

*Straight line characteristic, value being for higher figure in kilovolt range, i. e., range 0-5, 16 is for 5-KV.

Grounding.—This subject is partly covered in report for 1927 pp. 350-351, Bulletin 301, November, 1927, attention being given principally to permanent or emergency grounds for the purpose of permitting work to be safely done on normally energized parts of a substation—such as a circuit breaker or bus. Other aspects of the subject of "grounding" are considered in the following paragraphs.

Permanent "ground" (or earth potential) connections in either indoor or outdoor substations are made to the normally dead or de-energized parts, such as transformer cases, oil switch cases, structural steel work, etc. In fact, it is good practice to connect a permanent "ground" to every normally dead metallic part of the substation to insure protection to employes or others against direct or induced voltages, and lightning or static.

An exception to the desirability of universal "grounding" is cited in this paragraph covering switchboards. Panel supports for switchboards should be grounded except on grounded D.C. railway systems of 750 volts or less where only the isolated polarity is brought to the panel. Where such D.C. panels with ungrounded frames are installed in one board, together with A.C. panels with grounded frames, the panel support between the two sections of the board should be grounded, and the panel supporting bolts for this support should be covered by insulating caps.

Switchboard devices for operation at 150 volts or more above ground should have their exposed bare metal parts, which are insulated from the current-carrying parts, permanently grounded. This covers such items as A.C. instruments and meter cases, transformer frames, operating mechanism for switches, oil circuit breakers, rheostats, compensators, etc. Instrument transformer secondaries should be permanently grounded at the transformers. Steel frame work supporting high potential switching equipment should be carefully grounded at several points so as to prevent the possibility of high voltage occurring between sections of the steel work.

These permanent ground connections must be carefully made electrically to insure low resistance, and substantially made mechanically to prevent loss in case of physical damage. Their capacity for carrying current will depend upon what may be expected in event of fault of each individual case. It is better to have "ground" connections oversize rather than undersize and it is suggested that nothing less than number 2 AWG wire be used. It is desirable to have "ground" connections visible so that they may be readily inspected. Where they cannot be visible for their entire length it is not uncommon to group them at a common point prior to connecting them to earth, and labeling them to conform to equipment to which they are connected. It is well also to use copper bar, strap, or pipe for ground connections, rather than covered wire, because an employe may be less likely to cut it without asking questions.

Some equipment requires an independent "ground" connection, and in this classification we have lightning arresters. The conductor from lightning arresters to earth may be connected to similar conductors from other parts of the substation to earth but this is desirable only for the sake of added insurance so resulting.

In general, "ground" connections should not be run in iron conduit due to choking effect, particularly at high frequencies.

The method of insuring good contact with the earth varies, depending largely on local conditions. Good, permanent, low resistance grounds are essential. The efficiency is defeated by poor ground connections which weaken the protection and may cause ultimate loss of the apparatus. Careful attention given to construction and maintenance of grounds is amply justified by the greater reliability of protection secured. The greater the importance of the service, the greater is the need for good grounds and a regular system of testing and inspection. The character of the soil, the depth of permanent water or moisture level should be investigated before installing the ground elements. Valuable data on this can be obtained from the Government, Geologic Survey Reports and from City and County Engineering Department records. The number of grounds depends upon the character of the soil and size of the installation. In no case should less than two grounds be installed.

Usually ground contacts are made of steel rod, steel pipe or copper plates (or their equivalent), these being stated in the order of their ability to carry current. The steel rod is usually ⅝ inch diameter, and either galvanized or copper covered, and it is driven to permanent moisture level. Pipe grounds should be not less than 1 inch galvanized iron pipe driven into the ground to the permanent moisture level. A good way to install a pipe ground is to drive in a large pipe to a depth not less than five feet. Then remove it, drive in the permanent pipe, hold and pack around with rock salt soaked with water. Plate grounds should be copper plates placed below the moisture line. The plate should be packed in charcoal, and covered with at least six inches of sand. The top of the sand should be even with or below the permanent moisture level. Connections to the plate should be made with a standard copper cable fastened with copper rivets and straps. All the spaces around the straps should be filled with solder to prevent oxidization with its accompanying high resistance ground. Multiple ground contacts may be made using any number of the above devices at any given location, depending on the importance of the service. Salt or copper sulphate or other suitable material may reduce the resistance materially.

A systematic examination of the grounds and ground connections should be made periodically and a report kept on file showing exact plans of the location of ground plates, wires, etc., together with a brief description of the same. The actual electrical efficiency of a ground connection should be determined by a measurement of its resistance. The average value of a single pipe ground should be about 15 ohms.

Supplementing the subject matter of Bulletin 301 with respect to "emergency grounding" or "grounding for protection of men working on normally energized parts" it may be noted that work on substation feeders in the vicinity of the substation may be done by protecting at the substation bus, although this is open to the criticism that the men doing the work should place their own protection to prevent accidents as result of misunderstanding. The present tendency is to handle "grounding" for protection by means of fixed equipments and an auxiliary or transfer bus. In this case, however, it is desirable to so interlock the grounding equipment that an energized bus cannot be grounded by such fixed equipment in error. It should be understood also that in grounding multiphase lines or busses, each phase must be grounded.

Unit Type Substations.—This subject is briefly covered in 1927 report, p. 351 of Bulletin 301.

Unit design of substations may be defined as the association of one incoming high voltage cable with one step-down transformer, having no provision for interchanging cables or transformers by simple switching operations. In other words, with the unit design high voltage busses and circuit breakers are eliminated.

The following applies particularly to the high voltage power supply, for it is here that the characteristics of unit type design are most clearly seen.

The low voltage switching for feeders may be carried out in any manner regardless of the method of supplying sub-station transformers. In fact, there is a great variety of methods of supplying the distribution feeders as exhibited by the many sub-stations all over the country. Invariably, however, the low voltage arrangement provided a method for switching feeders to either a main or auxiliary bus.

The Unit Type Design gains greatest favor due to the simplification of the high voltage supply in the substation. All high voltage bus work may be eliminated, and, in fact, no high voltage breaker is needed at the transformer. Means should, however, be provided for disconnecting the incoming cable from the transformer. This may be done by disconnecting or air break switches. One operating company accomplishes this in a satisfactory and unique manner. The lead covered 3-conductor incoming cable is brought directly into an oil filled high voltage pothead box mounted on the transformer. This allows the high voltage apparatus to be entirely metal clad. Within this pothead box the cable conductors connect to the transformer terminals by disconnect links. Also incorporated in this box is a grounding switch which, when closed, places a solid ground on the transformer terminals.

The high voltage supply cables are always provided with an oil circuit breaker at the generating station end. The low voltage side of the transformer usually connects to the feeder busses through an oil circuit breaker. In case of failure of either a cable or transformer the relaying is arranged to open the breaker at the generating station and by overload protection and to open the low tension breaker by reverse power protection. Thus the cable and transformer is protected as a unit by very simple relaying. In contrast with this, the scheme of multiple switching on the high tension side requires a corresponding multiplicity of relays for full protection.

Another advantage in the unit type of layout frequently occurs from the possibility of selecting high voltage breakers of rupturing capacity lower than would be required with the multiple switching and high voltage bus arrangement. In the latter case it is usual for several incoming cables to tie in on a common high voltage bus, or at least to tie to a synchronizing bus through reactors. This means that in case of a high voltage failure in the substation the net resistance from the generating station to point of short circuit by parallel cables will be less than in the unit type design where there can be only one cable feeding a high tension failure. There may, therefore, be a considerable difference in rupturing capacity of breaker required by the two types of sub-station layout.

The unit type of design does not appear favorable to operating companies for those substations that are primarily a part of the transmission system, that is, in high voltage substations where the function is primarily one of transforming voltage and not supplying the distribution system. There are relatively few transformer banks and circuits, but each is of high capacity. The loss of either a circuit or transformer bank represents a high percentage loss of the total equipment, and therefore multiple switching is essential to insure maximum availability of all sound apparatus.

One obvious disadvantage of a unit type of substation design is that a given transformer can be supplied by only one cable. This means that the combination of cable and transformer is rendered inoperative whenever either part is faulty. Transformers as a rule are much more reliable than the cable circuits, hence in the unit system the reliability of supply to the substation is determined by the cables. The multiple switching arrangement, on the other hand, furnishes a flexibility whereby a faulty cable or transformer may be removed with a minimum reduction of equipment. This multiple switching also permits shifting loads on the transformers more readily.

While the foregoing, concerning unit design, has been based upon A.C. transformer and distribution substations, nevertheless the same principle of design is applicable to A.C.-D.C. converting substations. In this case the unit of converting equipment may consist of an incoming A.C. cable, oil circuit breaker, transformer, converters, and D.C. breaker.

One operating company has contemplated revamping their D.C. substations to secure this layout. Formerly the substations were arranged with a common A.C. bus. Due to growth in generating station capacity and paralleling of cable to substation the possible short circuit currents from A.C. faults far exceed the rupturing capacity of the A.C. breakers. By the change-over the A.C. bus will be eliminated and overload protection removed from the A.C. breakers. In event of failure of a cable or its connected transformer or converter this group of apparatus will be isolated, as a unit. The A.C. breaker at the generating station end of the cable will open by overload relaying and the D.C. breaker will open to reverse power protection.

The advantages and limitations of the unit system as enumerated for the A.C. substation also hold for the D.C. substation. However, the desire to avoid tieing converter and transformers to just one incoming cable is usually sufficiently strong so that this unit scheme does not gain much favor except in special cases such as mentioned above.

Conclusions

That the report covering the work of the Sub-Committee be accepted as a report of progress and the work continued.

Appendix O

(15) HIGH TENSION CABLES

J. A. Peabody, Chairman, Sub-Committee; J. T. Seaver, Vice-Chairman, Sub-Committee; J. H. Davis, C. L. Doub, H. C. Griffith, F. D. Hall, W. P. Monroe, L. S. Wells, Sidney Withington.

During the year new developments of importance on this subject have not come to the attention of the Sub-Committee.

It has been decided that this Sub-Committee shall confine its work to voltages over 25,000, as the American Engineering Standards Committee is working on the standardization of cables for voltages up to that amount.

Conclusions

It is recommended that this subject be continued.

Appendix P

(16) APPLICATION OF CORROSION-RESISTING MATERIALS TO RAILROAD ELECTRICAL CONSTRUCTION

R. P. Winton, Chairman, Sub-Committee; H. W. Pinkerton, Vice-Chairman, Sub-Committee; B. F. Bardo, J. S. Hagan, P. S. Mock, S. R. Negley, J. T. Seaver, J. S. Thorp.

The program of work for this Sub-Committee for this year was as follows:

1. Study of use of copper bearing structural steels for catenary bridges and transmission towers.

2. Study of corrosion resisting materials suitable for catenary messenger or catenary hardware.

Committee XV has been studying the use of copper bearing steel for structural purposes, but unfortunately no reports are available in regard to the life of this steel when exposed to the gases of steam locomotives. Copper bearing steel has been used for freight cars, and service tests over a period of fourteen years seem to indicate an increase in life of one-third to one-half that of plain open hearth steel.

Copper bearing steel is now being used for structural steel for bridegs, buildings, smoke stacks, etc. The Illinois Central Railroad has used copper bearing steel for catenary bridges, but these have not been in service long enough to give any conclusive evidence.

ALUMINUM AND ALUMINUM ALLOYS

Aluminum in the form of wire has been widely used for transmission lines. On account of the low tensile strength of aluminum, a steel core is usually used for additional strength. Aluminum resists the action of moisture or salt air well but should not be used in thin sections when exposed to the gases of steam locomotives. Various aluminum alloys, having great strength combined with light weight, have been developed. These alloys can be cast, forged, drawn and fabricated into hardware. There is not sufficient information available to predict the life of these alloys when exposed to atmospheric conditions on steam railroads.

CHROMIUM ALLOY STEEL

Various forms of chromium alloy steels or so-called "stainless steels," containing from 12 to 30 per cent chromium, have been recently developed. These steels are very resistant to salt water. Chromium steel can now be obtained in the form of wire having a tensile strength of over 175,000 lb. per square inch. The use of chromium steel for catenary messenger is still in the development stage but the results are promising. The present price is relatively high but may be reduced as production becomes greater.

COPPER COATED STEEL

Copper coated steel is manufactured by casting copper around a nearly molten steel billet. The ingot is then hot rolled into rods and cold drawn into wire. This material can be obtained in the form of wire having a tensile strength as high as 160,000 lb. per square inch. The life of copper coated steel depends on the uniformity and thickness of the coating. An outside layer of pure copper wire is usually used where stranded wire is used for catenary messenger. The copper wires provide additional conductivity and protection from the blast of steam locomotives.

NICKEL ALLOYS

Monel Metal is a natural alloy of the following approximate composition:

Nickel	67%
Copper	28%
Other metals (iron, manganese, silicon)	5%

The United States Bureau of Standards gives the following tensile properties for Monel Metal:

	Yield Point Lb. per Sq. In.	*Tensile Strength Lb. per Sq. In.*	*Elongation in 2 Inches*
Cold drawn rods	60,000- 90,000	80,000-110,000	20-30%
Sheets, annealed	25,000- 35,000	65,000- 75,000	35-45%
Sheets, hard	90,000-110,000	100,000-120,000	1- 2%
Wire, annealed	25,000- 35,000	65,000- 75,000	20-30%
Wire, hard	90,000-110,000	100,000-120,000	1- 2%
Castings	30,000- 40,000	65,000- 80,000	25-30%

Monel Metal is very resistant to atmospheric conditions except hydrochloric, nitric and sulphurous acid. Relatively rapid corrosion is experienced when exposed to the gases of steam locomotives.

A large number of Monel Metal pole line hardware fittings have been in service in the Panama Canal Zone for over thirteen years with very little corrosion.

COPPER

Hard drawn copper can be used in the form of wire, rods and bars. The hard drawing leaves a very brittle skin which will crack if bent or stamped. Copper resists gases of steam locomotives well but copper alloys having greater strength are available which resist corrosion nearly as well.

BRASS

The usual definition of 'brass" is a "simple copper, zinc alloy." Brasses cast well but the physical properties depend quite as much on the proper temperature control and foundry practice as the chemical composition. Brasses containing not more than 20 per cent zinc resist corrosion as well as bronze and are much cheaper. Brass containing more than 20 per cent zinc may corrode badly and develop so called "season cracks" when exposed to gases of steam locomotives. The properties of a satisfactory cast brass suitable for use on steam railroads is as follows:

Composition		*Tensile Strength*	*Yield Point*		*Brinell*
Copper	*Zinc*	*Lb. per Sq. In.*	*Lb. per Sq. In.*	*Elongation*	*Hardness*
80%	20%	32,000	7,750	40%	47%

"Low Brass" or "Red Brass" hard drawn wire containing 80 per cent copper and 20 per cent zinc suitable for messenger is available having the following properties:

Grade	*Tensile Strength Solid Wires Lb. per Sq. In.*	*Johnson Elastic Limit*	*Elongation in 60 Inches*	*Conductivity*
Hard drawn	116,000-127,000	60%	1.80-2.18%	20%
Medium drawn....	90,000	60%	....	20%

Medium drawn wire can be bent back flat on itself and is suitable for serving. Hard drawn wire cannot be served easily and is usually spliced in the field with some form of mechanical clamp.

BRONZE

The usual definition of "bronze" is a "simple copper, tin alloy." If other metals are present this metal is added as a prefix as, for example, "phosphor bronze." The properties of typical bronze castings suitable for hardware are as follows:

	A.S.T.M. Spec.	*Composition, Per Cent* Copper	Tin	Zinc	Lead	*Tensile Strength Lb. per Sq. In.*	*Yield Point Lb. per Sq. In.*	*Elongation in 2 Inches*
Sand Cast Alloy	B-60-26T	88	8	4	..	35,000	15,000	15%
Gun Metal	B-10-18	88	10	2	..	30,000	.....	14%
Ounce Metal ...	B-62-26T	85	5	5	5	26,000	12,000	15%

These bronzes are very resistant to the action of salt water and gases of steam locomotives. As in the case of brasses, the strength of bronze depends upon the proper foundry practice quite as much as the chemical composition.

Hard drawn bronze wire containing 98¾ per cent copper and 1¼ per cent tin suitable for contact wire or stranded messenger has the following properties:

Tensile Strength Lb. per Sq. In.	*Johnson Elastic Limit, in Per Cent of Tensile Strength*	*Elongation in 10 Inches*	*Conductivity*
70,000-92,000	65-75%	1-4%	40-45%

This bronze is very resistant to wear and corrosive action of gases of steam locomotives. The same alloy can be hot forged, drawn, stamped, cold headed and threaded.

High strength hard drawn bronze containing 97.3 per cent copper, 1.8 per cent tin and 1 per cent silicon suitable for stranded messenger has the following properties:

Tensile Strength Lb. per Sq. In.	*Johnson Elastic Limit, in Per Cent of Tensile Strength*	*Elongation in 10 Inches*	*Conductivity*
120,000-135,000	70-80%	1-4%	12-15%

The desirable properties of hard drawn bronzes depend in a large measure on proper rolling and drawing operations.

ALUMINUM BRONZE

An Aluminum Bronze is being manufactured for messenger cable containing approximately 95.5 per cent copper, 2.5 per cent aluminum and 2 per cent tin. Drawn wire has the following properties:

Ultimate Strength Solid Wires Lb. per Sq. In.	*Johnson Elastic Limit, in Per Cent of Tensile Strength*	*Elongation in 10 Inches*	*Conductivity*
126,000-133,000	60%	1.45-1.75%	15%

CADMIUM BRONZE

Cadmium bronze contact wire having great resistance to wear is available having the following properties:

Composition			*Tensile Strength, Lbs. per Sq. In.*	*Elongation in 10"*	*Conductivity*
Copper	*Cadium*	*Tin*			
99.5 %	0.5 %	....	59,000-61,000	3.00-3.25%	80%
99.25%	0.75%	....	60,000-71,500	1.00-4.00%	65-68%
98.5 %	1.0 %	0.5%	72,000-75,000	3.00%	55%

MANGANESE SILICON BRONZE

Bronze containing 96 per cent copper, 3 per cent manganese and 1 per cent silicon has been recently developed. This bronze can be cast, hot forged, rolled, drawn, stamped, cold-headed and threaded. The properties of various forms of this bronze are as follows:

Fabricated Forms:	*Ultimate Strength, Lbs. per Sq. In.*	*Elastic Limit, Lbs. per Sq. In.*	*Elongation in 2"*	*Brinell Hardness*
Green Sand Castings....	50,000	30,000	24%	115-130
Hot rolled rods	75,000	48,000	56%	125
Cold drawn rods........	110,000	70,000	15%	197
Forgings	64,000	40,000	54%	145

When two dissimilar metals are placed in contact in the presence of an electrolyte, an e.m.f. will be produced which will decompose the more positive metal. The following table gives the position of various commonly used metals in the electro chemical series arranged in order of the most positive first:

Aluminum
Chromium
Zinc
Iron
Nickel
Lead
Tin
Copper
Carbon

Experience has shown that iron in contact with copper or its alloys exposed to gases of steam locomotives, will deteriorate more rapidly than when alone.

Conclusions

1. That the study of corrosion resisting materials be continued.
2. That arrangement be made if possible for carrying on comprehensive tests of all available materials suitable for railroad electrical construction.

REPORT OF COMMITTEE IX—GRADE CROSSINGS

F. J. Stimson, *Chairman;*
F. D. Batchellor,
H. D. Blake,
Bernard Blum,
J. G. Brennan,
H. E. Brink,
R. E. Chamberlain,
C. W. Charleson,
L. B. Curtis,
A. F. Dorley,
G. N. Edmondson,
R. A. Feldes,
H. W. Fenno,
W. L. R. Haines,
L. C. Hartley,
M. V. Holmes,
G. C. Hughel,
Frank Ringer, *Vice-Chairman;*
Maro Johnson,
R. B. Kittredge,
A. E. Korsell,
A. C. Mackenzie,
H. C. Mann,
G. P. Palmer,
W. C. Pinschmidt,
J. W. Purdy,
L. J. Riegler,
E. H. Roth,
T. E. Rust,
H. M. Shepard,
M. D. Thompson,
W. J. Towne,
A. H. Utter,

Committee.

To the American Railway Engineering Association:

Your Committee on Grade Crossings submits the following report:

(1) Revision of Manual (Appendix A).

(2) Continue the study of methods for apportioning the cost of highway improvements adjacent to railway rights-of-way:

(a) Within incorporated limits of municipalities.

(b) Without incorporated limits of municipalities.

(3) Study and report on the comparative merits of various types of grade crossing protection, collaborating with Committee X—Signals and Interlocking (Appendix B).

(4) Continue the study of excessive number of highway grade crossings of railways, with methods for their removal.

(5) Continue the study and report on the economic aspects of grade crossing protection in lieu of grade separation (Appendix C).

(6) Study and report on the use of center columns for highway grade separations (Appendix D).

(7) Study and report on various types and locations of approach and warning signs for grade crossings, also the practices in the several states and federal requirements, with a view of securing uniformity of practice and standards (Appendix B).

(8) Continue the study and report on (a) Laws and regulations affecting the apportionment of Federal aid; (b) the proper form and character of division of costs of separation of grades as between the railway, state, county, municipal or other corporation.

(9) Evolve a formula which will develop and evaluate the relative benefits to the public and railways from:

(a) Grade crossing protection,

(b) Elimination of grade crossings,

(c) Reduction of traffic on highway grade crossings (Appendix E).

(10) Outline of work for ensuing year.

Bulletin 312, December, 1928.

The Committee deferred further active work on subjects (2), (4) and (8) in view of the action taken by the Association at last convention.

Action Recommended

(1) That the report on standard highway crossing sign be adopted and printed in the Manual (Appendix A).

(2) That the conclusions be adopted and printed in the Manual (Appendix B).

(3) That the report be received as information (Appendix C).

(4) That the report be received as information (Appendix D).

(5) That the conclusions be adopted and printed in the Manual (Appendix E).

Recommendations for Future Work

(1) Revision of Manual.

(2) Continue the investigation and report on the comparative merits of various types of grade crossing protection, collaborating with Committee X—Signals and Interlocking.

(3) Continue the study and report on the economic aspects of grade crossing protection in lieu of grade separation.

(4) Continue the investigation and report on the use of center columns for highway grade separations.

(5) Continue the study and report on a method for developing and evaluating the relative benefits to the public and railways from:

(a) Grade crossing protection.

(b) Elimination of grade crossings.

(c) Reduction of traffic on highway grade crossings.

(6) Develop a classification and form for recording and reporting highway grade crossing accidents, with a view to determining the relative extent of contributory causes, collaborating with the Safety Section of the American Railway Association, and the Association of Railway Claim Agents.

(7) Outline of work for ensuing year.

Respectfully submitted,

THE COMMITTEE ON GRADE CROSSINGS,

F. J. STIMSON, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

Maro Johnson, Chairman, Sub-Committee; A. F. Dorley, H. W. Fenno, A. E. Korsell, H. C. Mann, E. H. Roth.

HIGHWAY CROSSING SIGN

Following action of the 1928 convention, the Committee has given further consideration to the Highway Crossing Sign, particularly with reference to the use of an auxiliary sign indicating the number of tracks to be crossed, and has again submitted same to the membership for letter ballot. The result of this ballot is as follows:

For Highway Crossing Sign WITH indication showing number of tracks to be crossed.............	642 votes
For Highway Crossing Sign WITHOUT indication showing number of tracks to be crossed.........	309 votes
Against proposed Highway Crossing Sign...........	72 votes

The Committee, therefore, recommends the adoption of sign shown on following page for publication in the Manual as recommended practice.

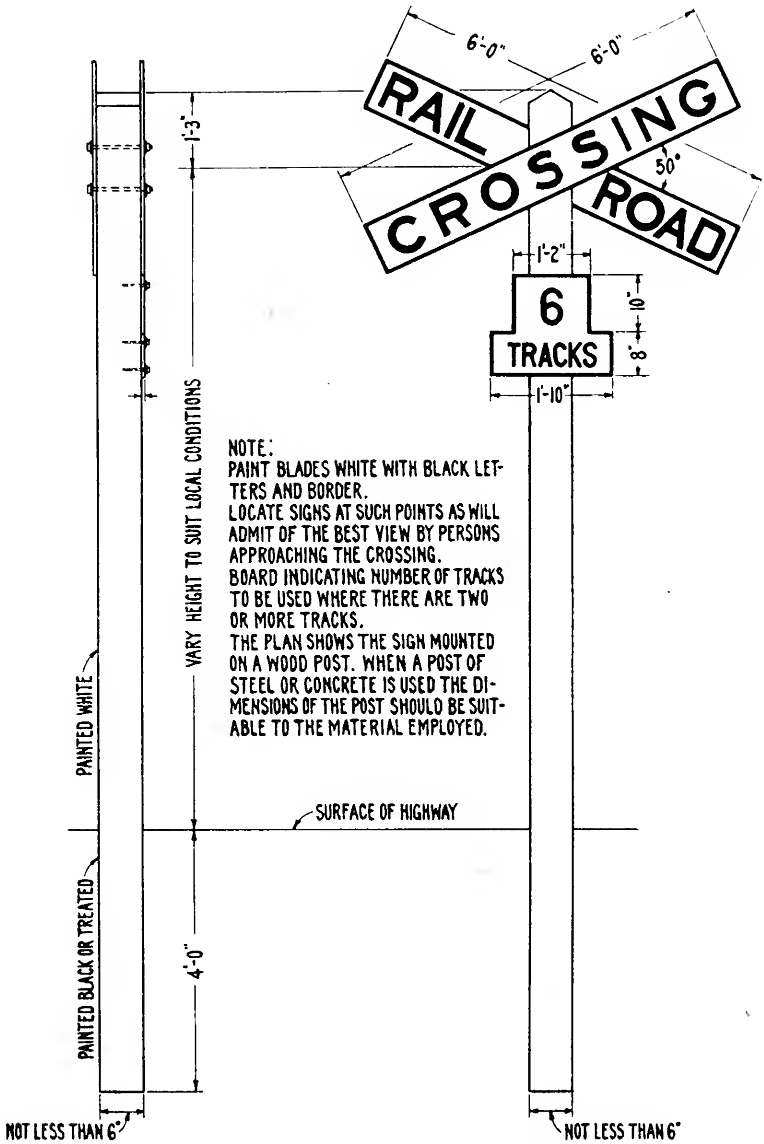
In connection with this, your Committee is advised that the Traffic Committee of the American Engineering Council, which was appointed at the request of the National Conference on Street and Highway Safety, has adopted the following specifications for sign at crossing of highways with railways:

"1. All railroad crossing signs shall be made of two arms mounted across each other in inclined positions to form a crossbuck;

"2. All signs shall be placed not more than 15 feet from the railroad crossing;

"3. Colors, black letters on white background."

It is expected that these specifications will be adopted at the next meeting of the National Conference.



Highway Crossing Sign

Appendix B

(2) THE COMPARATIVE MERITS OF VARIOUS TYPES OF GRADE CROSSING PROTECTION; VARIOUS TYPES AND LOCATIONS OF APPROACH AND WARNING SIGNS FOR GRADE CROSSINGS; PRACTICES IN THE SEVERAL STATES AND FEDERAL REQUIREMENTS

Bernard Blum, Chairman, Sub-Committee; H. D. Blake, G. N. Edmondson, M. V. Holmes, A. C. Mackenzie, H. M. Shepard.

The work for the current year has been a continuation of the study commenced two years ago. We have collaborated with Sub-Committee No. 3 of Committee X so as to avoid duplication of effort and to obtain the benefit of their technical skill. With the growing importance of the grade crossing problem, the increase in types of crossing protection has grown apace. While we do not desire to curtail proper development, or interfere with engineering advancement, it is our thought that the gains in the adoption of uniform protective signs, signals and methods are far more valuable than the questionable benefits of equipping our grade crossings with appealing devices, the advantages of which are at least debatable.

The desirability of having uniformity of practice and standards in grade crossing signs, signals and other protection seems self-evident, but frequently the objective is lost to view in the glamor of a new fashion. The protection to be afforded at a grade crossing is to warn the driver that he is approaching a railroad track, to provide a view in both directions for noting the approach of a train so he has ample time to stop, or to provide such protective devices as will notify him of the approach of a train.

There will probably always be some difference of opinion as to the best type of grade crossing protection, and it is not practicable to deduce formulæ to work out the most effective and economical type for any individual case, but we may learn from statistical data if there is an advantage that can be assigned to certain types of protection devices.

For a number of years there has been an increase in the number of automatic signals of the wigwag and flashlight type, and in a number of states, and on several railroads, they have replaced other types of protection. Where the conditions of travel on the highway or railroad justify more than fixed signs, it is our opinion that the wigwag or flashlight should be employed. There appears to be a difference of opinion among Engineers as to the relative merits of the two types, although the night indication is practically the same for both. Geographically there appear to be more flashlight signals east of the Mississippi River and more wigwags west thereof. It has therefore been suggested that this Committee make a compromise and recommend as standard practice that railroads east and west of the river adopt the flashlight and wigwag, respectively. Such an adoption does not appeal to us as a proper solution. The Board of Railway Commissioners of Canada have adopted the wigwag as the standard type of signal in that country. It seems important for the railroads in this country to standardize on crossing signals before the various State Commissions adopt differing standards, or statutes are enacted.

The advance warning sign with the letters R.R. in the upper half of the circle is in general use throughout the country, has been adopted by the American Association of Highway Officials, and is being rapidly introduced on nearly all trunk highways. It is our recommendation that this sign be placed in advance of all grade crossings and steps be taken to have the various State and Province legislatures require the maintenance of same be borne by the counties or municipalities.

At the 1928 convention the design of the approach sign was referred back to this Committee, in the words of the maker of the motion:

> "That a further and somewhat independent study is very desirable."

We believe that the present form of advance sign originated in the American Railway Association and has been generally adopted by the several Highway Commissions. The sign is distinctive and it is in general use throughout the country. It is impossible to meet the views of all in a matter of design and we offer the sign (a revision of the present standard A.R.A. sign) for adoption. Primarily the sign is a highway and not a railroad sign, and since its adoption by the Highway Departments, nothing but delay and confusion would ensue should we attempt a radical revision.

In Canada, the Board of Railway Commissioners have approved for advance warning sign, the standard crossbuck sign with a board below marked "300 feet." It is important that the same standards prevail on both sides of the border.

Adjacent to the nearest track at all grade crossings should be located the standard crossbuck, or highway crossing sign, one on each side of the railway. Where traffic densities on the railway and highway are such that additional protection is required, the wigwag or flashlight signal should be installed. Where the railway traffic permits, such signals should be operated automatically by the approaching trains. Where switching movements preclude the possibility of automatic operation, one or more crossings may be manually controlled to suit the requirements.

The question of location of the home or crossbuck sign has been one of much debate. There has been general agreement that the advance sign should be at the right side of the road, close to the paved or traveled portion of the highway. The advantages of having the home signal in the center of the roadway to divide the traffic, reduce speed, and avoid any question of the automobilist seeing the sign, has appealed to many railway engineers.

The State Highway Commissions are, in general, opposed to obstructions in the middle of their roads and insist on such signs and signals being located on the side. The Committee on Standard Codes of Street Traffic Signs, Signals and Markings of American Engineering Council advocate signals on the four corners of street intersections. For railway grade crossings, a corresponding arrangement is one on each side of the track on the righthand side of the road. The parking of machines along the curb in towns and cities may hide such signs and the center of road installation is recommended for crossings in towns. The objection that is raised to obstructions in the middle of high speed roads does not apply with equal force within municipalities.

In many states and provinces the location of whistle posts is prescribed by law to be one-quarter mile on either side of grade crossings, and whistles are to be sounded at that distance. With a train moving sixty miles per hour, there is an interval of fifteen seconds from the time the whistle starts to sound, and about eight or nine seconds from the time the whistling has ended until the engine reaches the crossing. In the case of higher-speed trains, the time of warning is correspondingly less. With modern high-speed automobiles this warning period is not long enough. It has been suggested that whistle posts should be located at a distance from the crossing to enable the fastest trains operated to give warning twenty seconds before arrival at the crossing. There is danger that there will be too long an interval after whistling by slower trains before reaching the crossing, and a fast automobile driver might have been too far away to have heard the whistle. A remedy for this would be to have the engineman whistle twice for the crossing.

This brings up the subject of distance that engine whistles can be heard. In a closed automobile, in stormy weather with the wind blowing toward the locomotive, the whistle is not heard at a great distance, and it appears to your Committee that the solution of the problem is to locate the whistle post, not at a fixed distance from the crossing to be protected, but at such a distance as will give proper warning under the operating conditions. In addition, sirens should be placed on locomotives ahead of the stack to take the place of the ordinary steam whistle for crossing signals.

In some states there are laws or regulations requiring that signs be placed at crossings protected by watchmen, or manually controlled signals, showing the hours during which such protection is afforded. Frequently the wording of such signs does not give the correct information, as hours of watchmen's service have been changed since the sign was originally placed. It is important that members see that such signs give accurately the hours of duty.

In some places flashing type advertising signs are employed. Such signs may be mistaken for flashing light crossing signals, or through their continuous flashing bring about a disregard of wigwags or flashing type signals. It is our recommendation that the members interest themselves to promote the passage of laws prohibiting the use of these flashing signs along highways.

Following is a summarized statement of comparison of various protected grade crossings in the United States as reported by the Interstate Commerce Commission for the ends of the respective years:

Kind of Protection	*1925*	*1926*	*1927*
Gates	6,386	6,170	5,957
Watchmen	7,935	7,765	7,554
Signals	12,964	13,992	15,213
Fixed Signs	202,348	202,620	203,817
Total	229,633	230,547	232,541
Otherwise Unprotected	4,068	4,611	3,742
Grand Total	233,701	235,158	236,283
Increase	.....	1,457	1,125

It is to be noted that the number of crossings protected by gates or watchmen is decreasing, and those protected by fixed signals is increasing. The net increase in number of grade crossings is disturbing in view of the number that should be eliminated through highway relocation and grade separation work.

The following tables of grade crossing accidents are of interest:

Grade Crossing Accidents Divided as to Type of Protection

Kind of Protection	*Number Accidents*			*Killed*			*Injured*		
	1925	1926	1927	1925	1926	1927	1925	1926	1927
Gates	210	227	192	115	100	105	143	175	126
Watchmen	568	603	606	164	195	181	734	718	798
Signals	777	884	922	392	478	448	867	999	1025
Fixed Signs	3897	4148	3876	1535	1718	1637	4811	5099	4664
Totals	5452	5862	5596	2206	2491	2371	6555	6991	6613

Deaths and Injuries Divided as to Type of Conveyance

	Killed			*Injured*		
	1925	*1926*	*1927*	*1925*	*1926*	*1927*
Motor propelled	1797	2080	1992	5938	6371	6085
Animal drawn	62	49	33	155	126	100
Pedestrian	299	300	299	273	261	219
Miscellaneous	48	62	47	189	233	209
Totals	2206	2491	2371	6555	6991	6613

The number of motor vehicles registered as of December 31st of each year was as follows:

1925—19,954,357
1926—22,046,957
1927—23,127,000

The ratio of accidents to total number of licensed motor vehicles is shown in the following table:

Killed	*Injured*
1925—1 to 11,104 vehicles	1 to 3,360 vehicles
1926—1 to 10,599 vehicles	1 to 3,460 vehicles
1927—1 to 11,610 vehicles	1 to 3,800 vehicles

In conference with Committee X, it was agreed that Committee would report on the subject of Automatic Crossing Gates and cover for this year a newly-designed automatic signal which operates the highway standard octagonal stop sign.

A number of states require the use of Highway Stop Signs at specially designated crossings and there is shown in Fig. 3 the present standard sign that is employed; Fig. 6 shows a typical crossing with location of signs.

STATEMENT OF ADVANCE WARNING SIGNS AT HIGHWAY CROSSINGS

States	Approach Signs Required by Law	Cost of Installation Borne by	Cost of Maintenance Borne by	Kind of Sign	Location	Remarks
Alabama	No					Stop sign required.
Arizona	No	State	State	Std. R. R.	400′	No reply.
Arkansas	Yes			Std. R. R.	300′	
California	Yes	Co. or City	Co. or City	Std. R. R.		Reasonable white background.
Colorado				Std. R. R.		
Connecticut	Yes	Railway	Railway	Std. R. R.		White instead of yellow background.
Delaware	No	Not uniform		Std. R. R.		No reply.
Florida	Yes			Std. R. R.	250′	Also red reflector.
Georgia				Std. R. R.		
Idaho	No			Std. R. R.	500′	
Illinois	Yes	State	State	Std. R. R.	300′	White instead of yellow background. Ry. to place "Stop" sign where ordered.
Indiana	Yes	Railway	Counties	Std. R. R.	300′	White instead of yellow background where R. R. has more than 1 track "Multiple Crossing."
Iowa	No			Std. R. R.		
Kansas	No			Std. R. R.	400′	
Kentucky	No			Std. R. R.	350′	"Stop" sign 25′ from track required by law at dangerous crossings.
Louisiana	No					Stop sign required.
Maine				Std. R. R.		White instead of yellow background. Reflectors at dangerous crossings.
Massachusetts	Yes	Local Authorities	Local Authorities	Std. R. R.	300′	
Maryland	No	State	State	Disc with red center	450′	
Michigan	Yes			Std. R. R.	500′	Cast iron, white background.
Minnesota	Yes			Std. R. R.		
Mississippi						On Federal Aid Projects. Railroads required by law to furnish "Mississippi Law Stop."
Missouri	No			Std. R. R.	350′ to 450′	"Stop" signs placed at blind crossings.
Montana						None being placed at this time.
Nebraska	No			Std. R. R.	350′to300′	Stop signs required.
Nevada	No			Std. R. R.		Red reflectors in addition.
New Hampshire	Yes Act 1915	Local Authorities	Local Authorities	Std. R. R.	300′	White instead of yellow background.
New Jersey	No			Std. R. R.	250′	White instead of yellow background.
New Mexico	No			Std. R. R.		
New York	Yes	Railway	Local Authorities	Std. R. R.		White instead of yellow background.
N. Carolina	Yes, 1923	Railway	Railway	50″x40″ White field black letters bearing "N. C. Law-Stop"	100′	Small sign beneath showing number of tracks.

States	Approach Signs Required by Law	Cost of Installation Borne by	Cost of Maintenance Borne by	Kind of Sign	Location	Remarks
N. Dakota	Yes			Std. R. R.	350′	
Ohio	No			Std. R. R.	350′	Initials of R. R. shown in lower half.
Oklahoma	Yes	Railway	Railway	2′ 2″ x 3″ White sheet iron, black letters, "Stop-State Law."		
Oregon	Yes			Std. R. R.	300′	White instead of yellow background. Red reflector in addition.
Pennsylvania	No	Railway	State	Std. R. R.	300′	White instead of yellow background.
Rhode Island	No			Std. R. R.		
S. Carolina	No			Std. R. R.		
S. Dakota	Yes			Std. R. R.		
Tennessee				Std. R. R.	300′ to 600′	Std. stop sign in addition.
Texas						Under consideration.
Utah	No			Various		Beginning to use Std. signs.
Vermont	No			Std. R. R.	200′ to 300′	
Virginia	No	Railway	State	Std. R. R.	200′	On same post "R. R. 200 ft.—speed 5 miles per hour."
Washington	No			Std. R. R.	500′	
Wisconsin	Yes			Std. R. R.	350′ to 500′	
Wyoming	No			Std. R. R.		

Summary

Number of States requiring signs.............................. 17
Number of States requiring railways to bear cost.............. 7
Number of States using standard railroad signs................ 38

Conclusions

1. We recommend that the flashlight, Fig. 1, or wigwag signal, Fig. 2, be adopted and placed in the Manual as recommended practice for installation at busy crossings and for replacing gates and watchmen.

2. We recommend that the advance warning sign as shown by Fig. 3 be approved as recommended practice and placed in the Manual.

3. We recommend that wherever wigwag or flashlight signals are used, two shall be used at each crossing, one on each side of the track, and that in cities and towns, when the street is of sufficient width, the signals shall be located in the center of the street. Recommended practice is shown in Fig. 4 and Fig. 5.

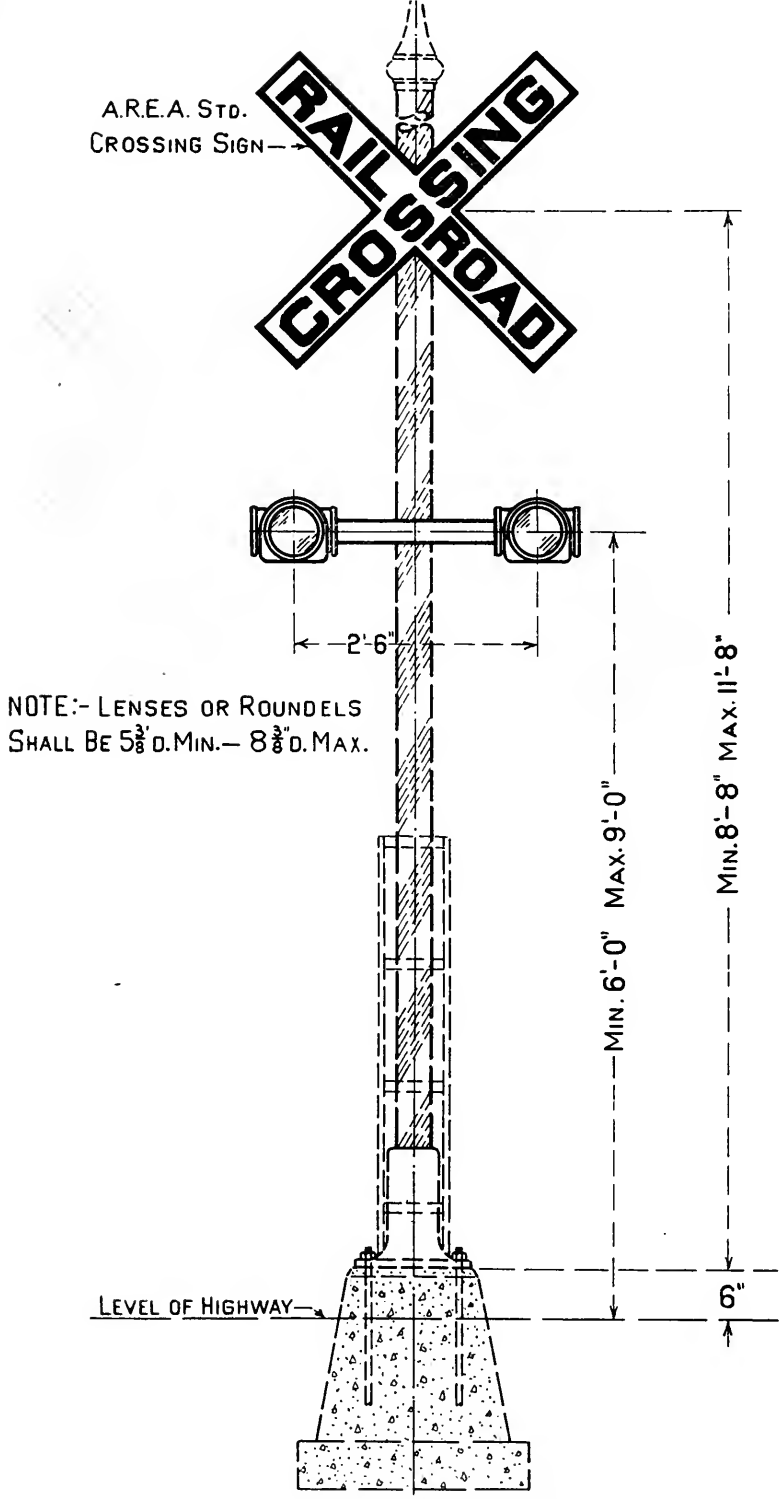


Fig. 1—Highway Crossing Signal
Flashing Light

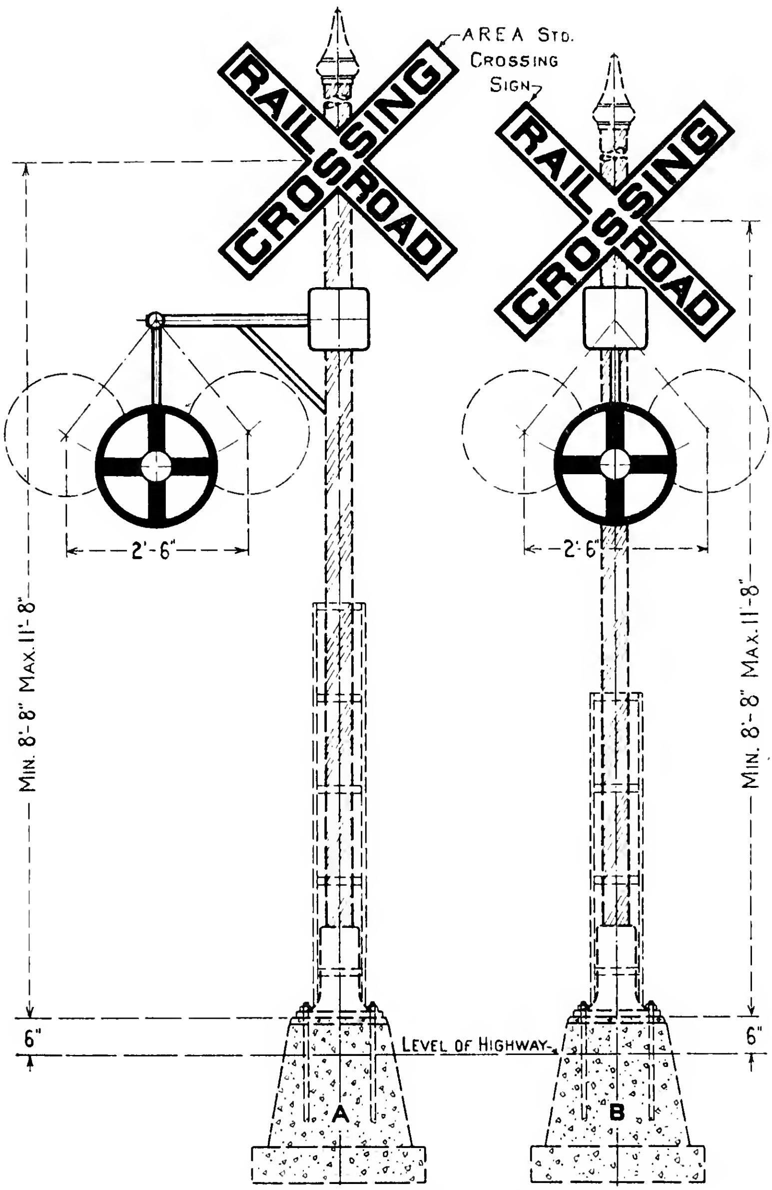
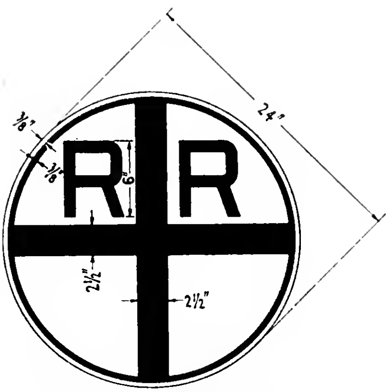
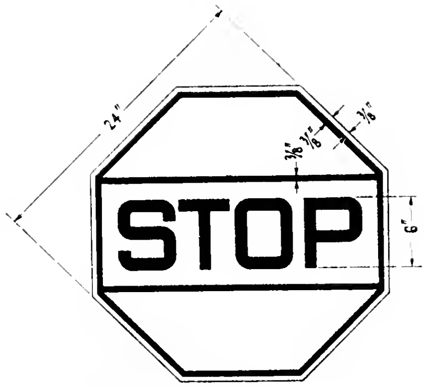


Fig 2—Highway Crossing Signal
Wigwag

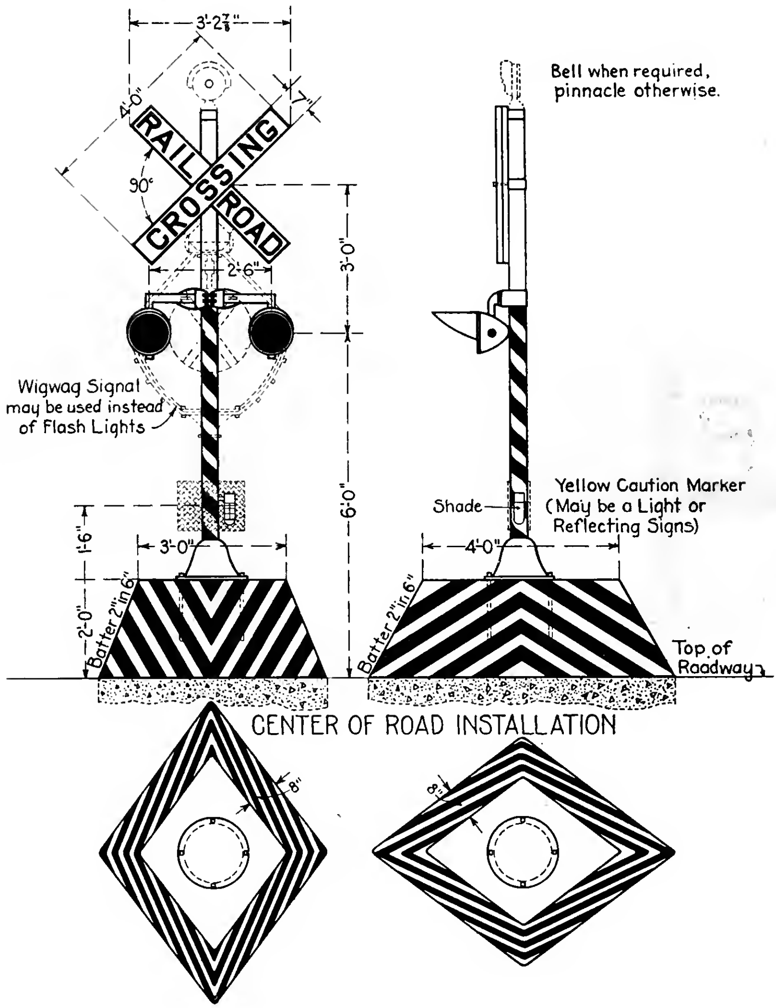


Advance Highway Crossing Sign



Stop Sign
To be used when required by law or regulation

FIG. 3—WARNING SIGNS. MARKERS TO BE LETTERED IN BLACK ON LEMON YELLOW GROUND



3'-2⅞"
4'-0"
7"
RAIL ROAD
CROSSING
90°
2'-6"
3'-0"
6'-0"
Wigwag Signal may be used instead of Flash Lights
1'-6"
3'-0"
2'-0"
Batter 2" in 6"
Bell when required, pinnacle otherwise.
Shade
Yellow Caution Marker (May be a Light or Reflecting Signs)
4'-0"
Batter 2" in 6"
Top of Roadway
CENTER OF ROAD INSTALLATION
8"
8"

Fig. 4

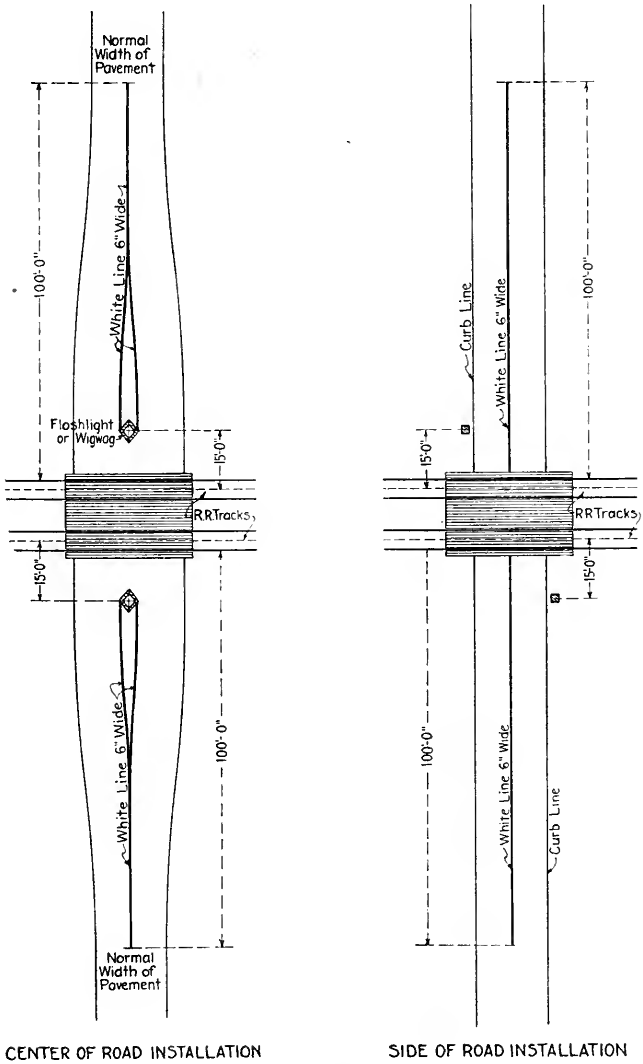

Normal
Width of
Pavement
100'-0"
White Line 6" Wide
Flashlight
or Wigwag
15'-0"
R.R.Tracks
15'-0"
White Line 6" Wide
100'-0"
Normal
Width of
Pavement
CENTER OF ROAD INSTALLATION
Curb Line
White Line 6" Wide
100'-0"
15'-0"
RRTracks
15'-0"
100'-0"
White Line 6" Wide
Curb Line
SIDE OF ROAD INSTALLATION

Fig. 5

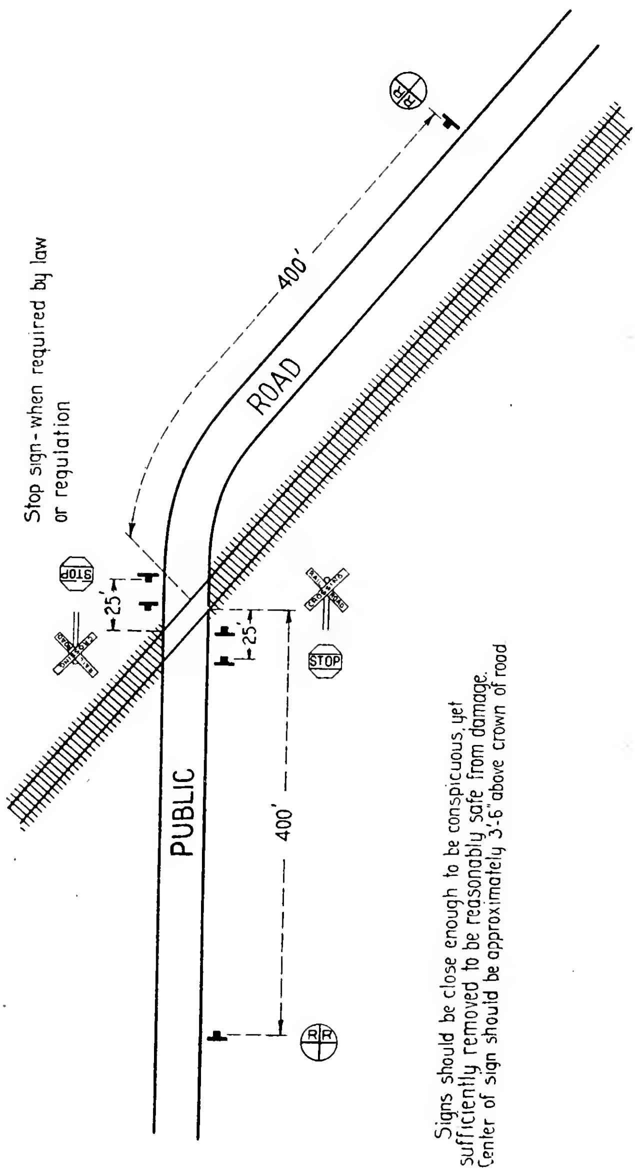


FIG. 6—TYPICAL MARKING RAILROAD CROSSING

Appendix C

(5) CONTINUE THE STUDY AND REPORT ON THE ECONOMIC ASPECTS OF GRADE CROSSING PROTECTION IN LIEU OF GRADE CROSSING SEPARATION

A. H. Utter, Chairman, Sub-Committee; F. D. Batchellor, H. D. Blake, J. G. Brennan, R. A. Feldes, L. C. Hartley, G. P. Palmer, L. J. Riegler, E. H. Roth, T. E. Rust, W. J. Towne.

The Sub-Committee has held two meetings during the year in addition to the meetings of the entire Committee, and secured information upon which to formulate a progress report. It is, however, necessary to have this information in such detailed form as to reduce it to a unit basis, which is the purpose of next year's work.

The following tabulation is the result of the study thus far.

Type of Protection	No. of Roads Reporting	Depreciation	Interest 5½ Per Cent	Annual Mtce. and Operation	Total Annual Cost	Annual Cost Capitalized at 5½ Per Cent
Watchmen..........	8	$ 8.24	$ 9.54	$2851.23	$2869.03	$52,000
Gates..............	11	86.59	95.10	3069.65	3251.35	59,000
Flash Lights.......	10	93.09	105.27	256.30	454.66	8,300
Wig Wags..........	7	90.32	106.96	245.20	442.58	8,000
Spl. Fixed Signs....	4	1.71	1.53	9.44	12.68	250

It is recommended that the report be received as information and the study of the subject continued next year.

Appendix D

(6) THE USE OF CENTER COLUMNS FOR HIGHWAY GRADE SEPARATIONS

J. G. Brennan, Chairman, Sub-Committee; R. E. Chamberlain, C. W. Charleson, L. B. Curtiss, G. P. Palmer, J. W. Purdy.

The Committee is endeavoring to obtain accurate information from all the states of the United States and Canada and from cities of 200,000, or over, in population, regarding the laws, ordinances and other requirements governing the use of center columns in highway railroad grade crossing elimination work. The purpose is to summarize this information so that it may be available for use in a later study to be made to determine definite recommendations for the use of center columns.

The Committee has sent out a circular to obtain this information, but to date the information is incomplete and it is recommended that the work of the Committee be extended to the year 1929.

Appendix E

(5) EVOLVE A FORMULA WHICH WILL DEVELOP AND EVALUATE THE RELATIVE BENEFITS TO THE PUBLIC AND RAILWAYS FROM:

(a) Grade Crossing Protection.
(b) Elimination of Grade Crossings.
(c) Reduction of Traffic on Highway Grade Crossings

R. B. Kittredge, Chairman, Sub-Committee; F. D. Batchellor, H. D. Blake, H. E. Brink, W. L. R. Haines, G. C. Hughel, Frank Ringer, T. E. Rust, M. D. Thompson.

(a) GRADE-CROSSING PROTECTION

The principal benefit from grade-crossing protection is the reduction in the number of crossing accidents. To the railways this should result in a decrease in expenses; to the users of the highways it means added convenience and safety.

To develop a formula for accurately determining the relative benefits accruing to the railways and to the public from grade-crossing protection is difficult, if not impossible, but justice and sound economics demand that both the railways and the users of the highways share in the costs.

That the railways should contribute to the cost of grade-crossing protection is so generally admitted as to need no development, but except in a few states the practice has been to require the railways to pay the entire cost of grade-crossing protection.

As it is found impossible to eliminate all grade crossings, the growing importance of traffic on the highways is resulting in an increasing demand for grade-crossing protection. To throw the entire burden of expense upon the railways is neither fair nor in the best interests of either the railways or the public. With the increasing competition between transportation agencies, the best interests of the public, as well as of the railways, demand that those costs which properly belong to it be charged against each agency of transportation, whether by air, by water, by highway, or by rail.

The demand for grade-crossing improvements arises in general not from any change in railway operation but from the change in character and increase in volume of traffic on the highways. The responsibility of a man who goes upon a railroad track for finding out whether a train is dangerously near has been clearly defined by the United States Supreme Court. At many highway crossings at grade, where the highway traffic is normally small in volume, fixed crossing signs, warning travelers of the existence of a railroad, are sufficient protection. When the volume of highway traffic is greater, watchmen, gates, or automatic signals, notifying travelers of approaching trains, afford ample protection for the drivers of vehicles who use reasonable care. No amount of money spent on grade-crossing improvements will completely protect the reckless driver, and penalties provided by law should be rigorously imposed upon drivers who fail to heed warning signs.

The maximum benefit from grade-crossing protection will be obtained when protective devices of standard types are installed throughout the country under uniform regulations and practices.

(b) ELIMINATION OF GRADE CROSSINGS

For the ordinary crossing, the cost to the railway of elimination is ordinarily not justified economically. The elimination of hazard and reduction of cost of protection otherwise required and of damage claims usually result in but small decrease in costs of operation and maintenance. In cities and towns where railway traffic is heavy, the elimination of grade crossings will be of increased benefit to the railways if it results in the removal of existing railway restrictions.

The benefits to the users of the highways from grade-crossing elimination include the elimination of hazard, the increase in capacity of the highway, and, what is frequently the real reason for the demand for doing away with the grade crossing, particularly in cities and towns, the elimination of delay to highway traffic due to the crossing being blocked by railway traffic.

Many efforts have been made to develop a formula to determine the relative benefits to the railways and to the public from the elimination of grade crossings. Those who have given the problem careful thought are generally of the opinion that on account of the many variable conditions and the difficulty in expressing the benefits in terms of money, division of cost must be on a more or less arbitrary basis determined by the circumstances and conditions affecting the particular crossing.

The idea that the railways ought to pay 100 per cent of the cost of grade crossing elimination has long been discarded by all who have given intelligent thought to the problem, although probably few will yet agree with those who maintain that, whatever the immediate distribution of costs, the public eventually pays.

The building of the main highways of the United States is now generally accepted as a State and Federal responsibility, and the social and educational advantages of improved highways, together with the increase in property values and reduction in motor-vehicle costs, are believed to justify the enormous expenditures that are being made for the improvement of our highway system.

Grade-crossing elimination has not kept pace with the other phases of highway development, and many gaps have been left in our improved highways at grade-crossings, largely because the methods used for financing grade-crossing improvements have been based on conditions existing before the development of motor vehicles had so tremendously increased the importance of travel on our highways. Even some railway representatives have been slow to recognize the significance of the enormous growth in highway traffic and have been willing to commit their roads to a division of costs that not only puts an unfair burden on the railways for the improvements actually made, but, what is perhaps even more important, seriously delays progress in the solution of grade-crossing problems.

In the present stage of development of our transportation systems this Committee believes that a division of the costs of grade-crossing elimination much more favorable to the railways, will not only be more equitable than the present common practice, but will also be of additional benefit to everybody concerned in that it will result in more rapid progress in a reasonable program of grade-crossing elimination.

(c) REDUCTION IN TRAFFIC AT GRADE CROSSINGS

When a separation structure is built to carry a part of the traffic now using a grade crossing, or a relocation of a highway is effected principally to divert some of the highway traffic from a grade crossing, but the grade crossing must be retained for the use of a part of the highway traffic, the benefits to the railway are very much less than if the grade crossing could be abandoned and closed. The reduction in traffic over the grade crossing, so long as that reduction is effective, will result in some reduction in hazard, and probably in damage claims, but the expense of crossing maintenance and protection will continue, and the possibility exists that the highway traffic over the grade crossing may again grow to serious proportions.

Plans and agreements for grade separations and highway relocations should provide, so far as practicable, for the abandonment and closing of the existing grade crossings, but, if a grade crossing must be retained for the use of a part of the highway traffic, the railway's direct contribution to the cost of the improvement should be reduced. If the highway traffic diverted from the crossing is of sufficient importance to justify the improvement, the safety and expedition of this traffic will constitute the principal benefits.

The co-operation of railway and highway officials is essential to reasonable progress in grade-crossing improvements. The railways should often be expected to pay some part of the cost of improvements that effect a substantial reduction in highway traffic over a grade crossing, but highway officials should be willing to recognize that unless the existing grade crossing is abandoned and closed, the benefits to the railway are comparatively small.

Conclusions

The conclusions of the Committee are as follows:

1. In determination of the relative benefits to the public and railroads from (a) protection of highway grade crossings, (b) elimination of highway grade crossings and (c) reduction of traffic on highway grade crossings, consideration should be given to the following general principles:

(a) Creation of new grade crossings should be avoided.

(b) In the construction and improvement of highways and railroads, provision should be made for the elimination of existing highway grade crossings, including crossings of local roads where the road traffic can be diverted to the main highways.

(c) Plans and agreements for highway crossing separations should provide for the abandonment and closing of the existing grade crossings carrying the same highway traffic.

(d) Where the expense of grade crossing elimination or separation is not justified, protection should be provided. The character of protection should depend upon local conditions and the character and volume of traffic.

(e) Increasing need for grade crossing protection is brought about principally by change in character and increase in volume of highway traffic. The benefit from such protection will accrue in greater proportion to users of the highway and the cost should be shared accordingly by state and municipal authorities.

(f) The elimination or protection of highway grade crossings is of such importance, and involves the public safety to such an extent, that primary consideration should be given to such improvements in the allocation of capital by the railroads for safety measures designed to protect the public, and also in the allocation of funds made available by the Federal aid act and other legislation for highway improvements.

(g) The order in which grade crossing elimination projects should be undertaken depends upon many varying factors, and should be fixed by a study of the local conditions at each crossing, care being taken to see that the greatest safety and expedition in the movement of traffic are secured for the money expended. Primary consideration should be given to the elimination of grade crossings at which extra hazard exists by reason of traffic and physical conditions.

2. The relative benefits to the public and railroads from grade crossing protection, elimination, or reduction of traffic, cannot be evaluated by a formula, but must be arrived at in the light of reasoned judgment, having in view all the conditions and factors affecting the particular crossing. Among the elements to be considered are:

(a) Physical conditions:
  1. Alinement.
  2. Grades.
  3. Visibility.
  4. Drainage.
  5. Character and cost of highway and railroad construction.

(b) Railroad traffic:
  1. Number and speed of trains.

(c) Highway traffic:
  1. Number of automobiles.
  2. Number of trucks.
  3. Number of horse drawn vehicles.
  4. Relative proportion of local and through highway traffic.

(d) Federal and state laws and regulations.

3. The Committee desires to emphasize the necessity for sincere co-operation between railway and highway officials in the consideration of grade crossing problems.

REPORT OF COMMITTEE X—SIGNALS AND INTERLOCKING

W. M. Post, *Chairman;*
W. E. Boland,
W. J. Eck,
W. H. Elliott,
G. E. Ellis,
P. M. Gault,
J. V. Hanna,
J. C. Mock,
H. G. Morgan,
J. A. Peabody,
F. W. Pfleging, *Vice-Chairman;*
A. H. Rudd,
T. S. Stevens,
E. G. Stradling,
C. H. Tillett,
W. M. Vandersluis,
R. C. White,
F. B. Wiegand,
L. Wyant.

Committee.

To the American Railway Engineering Association:

Your Committee on Signals and Interlocking submits report on the following assignments:

1. Revision of Manual. (No revisions are recommended.)

2. Report on developments of automatic train control, collaborating with Train Control Committee, A.R.A. (Appendix A).

3. Report developments of automatic highway crossing protection, collaborating with Committee IX—Grade Crossings (Appendix B).

4. Report on increased efficiency secured in railway operation by signal indications in lieu of train orders and timetable superiorities, collaborating with Committee XXI—Economics of Railway Operation (Appendix C).

5. Prepare and submit as information a synopsis of the principal current activities of the Signal Section, A.R.A., supplemented with list and reference by number of adopted specifications, designs and principles of signaling practice (Appendix D).

Action Recommended

1. No revisions of the Manual are recommended.

2. That the report in Appendix A, relating to developments of automatic train control, be accepted as information.

3. That the report in Appendix B, concerning the development of automatic highway crossing protection, be accepted as information.

4. That the report in Appendix C, on increased efficiency secured in railway operation by signal indication in lieu of train orders and timetable superiorities, be accepted as information.

5. That the report in Appendix D, giving a synopsis of the principal activities of the Signal Section, A.R.A., together with a list of adopted specifications, designs and principles of signaling practice, be accepted as information.

Bulletin 312, December, 1928.

Recommended Outline of Work for the Ensuing Year

1. Revision of Manual.

2. Report developments of automatic train control, collaborating with Train Control Committee, A.R.A.

3. Report developments of automatic highway crossing protection, collaborating with Committee IX—Grade Crossings.

4. Report on increased efficiency secured in railway operation by signal indications in lieu of train orders and timetable superiorities, collaborating with Committee XXI—Economics of Railway Operation.

5. Prepare and submit as information a synopsis of the principal current activities of the Signal Section, A.R.A., supplemented with list and reference by number of adopted specifications, designs and principles of signaling practice.

6. Outline of work for ensuing year.

Respectfully submitted,

THE COMMITTEE ON SIGNALS AND INTERLOCKING,

W. M. POST, *Chairman.*

Appendix A

(2) AUTOMATIC TRAIN CONTROL

G. E. Ellis, Chairman, Sub-Committee; R. C. White, J. C. Mock.

There have been no important developments in the automatic train control field since the publication of the last report in Vol. 29, page 642. No orders have been issued by the Commission regarding the installation of train control, except such as extended the time for completion, or affected the equipment of certain locomotives in accordance with the Commission's orders.

Progress

There has been no change in the number of roads required to make an installation, but four of the carriers mentioned in the order, Chicago & North Western, Michigan Central, New York Central and Southern Railway, have made voluntary installations. Information concerning these voluntary installations is shown in Exhibit B. The Pennsylvania Railroad is arranging for a cab signal installation between New York and Philadelphia. All the installations ordered by the Commission have been completed, except a portion of the second order in one case. There have been some minor changes in addition to the voluntary installations in the mileage involved, and for the same reason, some changes in the locomotives. Exhibit A gives the latest information concerning installations made and engines equipped. These figures have been compiled from the records of the Committee on Automatic Train Control of the American Railway Association.

I.C.C. Inspections and Approvals

As of September 1, 1928, inspections have been made on forty-two installations under the first order, and twenty-eight under the second order, and inspections have also been made of one of the voluntary installations, that of the Michigan Central, previously referred to. Reports have been issued by the Commission on sixty-three of these inspections. Exhibit C gives in abstract the Exceptions, Requirements and Recommendations., etc., made in each of these reports issued since the list published in Exhibit B of Vol. 28. These have been arranged in the order issued by the Commission, and not according to devices. Most of these have been printed by the Commission, and the complete report can be secured from the Government Printing Office. Where such reports have been printed, the I.C.C. Opinion Number given in the heading of each report is the reference or file number used by the Government Printing Office.

Later and more complete information can be secured from the information issued and the bulletins prepared by the Committee on Automatic Train Control of the American Railway Association.

Exhibit A

TRACK MILEAGE AND LOCOMOTIVES EQUIPPED UNDER FIRST AND SECOND I.C.C. ORDERS AS OF SEPTEMBER 1, 1928.

Road	*Track Miles*	*Locomotives*	
A.T.&S. F.	349.77	87	
A.C.L.	577.54	135	
B.&O.	258.6	241	
B.&A.	485.82	242	
B.&M.	203.9	137	First order only—second order suspended
B.R.&P.			Exempt both orders
C.R.R.N.J.	170.4	124	
C.&O.	125.0	63	
C.&A.	203.5	48	First order only—second order suspended
C.&E.I.	288.2	147	
C.&E.			Exempt both orders
C.&N.W.	712.0	192	
C.B.&Q.	244.2	102	
C.I.&L.	161.0	50	
C.M.St.P.&P.	422.3	97	
C.R.I.&P.	564.5	163	
C.St.P.M.&O.			Exempt both orders
C.N.O.&T.P.	492.7	179	
C.C.C.&St.L.	376.9	103	
D.&H.	279.35	161	
D.L.&W.	544.86	201	
Erie	483.4	157	
G.N.	255.87	62	
I.C.	341.1	106	
K.C.S.			Both orders suspended
L.V.	659.6	325	
L.I.	88.0	269	
L.&N.	301.0	93	
M.C.	378.92	239	
M.P.	50.0	39	First order only—second order suspended
N.Y.C.	1257.21	1267	
N.Y.C.&St.L.	157.54	57	First order only—second order suspended
N.Y.N.H.&H.	331.6	238	
N.&W.	238.7	85	
N.P.	215.6	43	
O.W.R.R.&N.	86.1	33	First order only—second order exempt
Pa.	653.2	443	
P.M.	148.6	99	
P.C.C.&St.L.	726.27	439	
P.&L.E.	232.3	116	First order only—second order exempt
Reading	204.6	130	
R.F.&P.*	208.86	75	First order only—not included in second order
St.L.-S.F.	115.4	108	
S.P.	225.5	212	
Southern	608.04	107	
T.&N.O.	170.14	61	
U.P.	450.0	130	
W.J.&S.	112.4	129	First order only—not included in second order
W.M.			Exempt both orders
Total	15,160.49	7534	

*Includes 5.66 track miles equipped for operation of A.C.L. trains.

Exhibit B

ADDITIONAL INSTALLATIONS NOT INCLUDED IN EITHER ORDER

	Miles Road	*Miles Track*	*Engines*
SOUTHERN RAILWAY			
Salisbury to Asheville, N. C.	140.7	147.2	70
Asheville to Morristown, N. C.	88.0	93.0	59
Biltmore to Hayne, N. C.	66.0	69.0	22
Charlotte, N. C., to Columbia, S. C.	109.0	109.0	25
Bristol, Tenn., to Morristown, N. C.	89.0	89.0	21
Morristown, N. C., to Knoxville, Tenn.	42.0	84.0	..
Knoxville to Coltewah, Tenn.	96.0	98.0	20
Chattanooga, Tenn., to Atlanta, Ga.	149.0	179.0	40
Atlanta to Macon, Ga.	86.0	91.0	..
Macon, Ga., to Jacksonville, Fla.	260.8	266.8	53
Stevenson to Memphis, Tenn.	275.0	282.0	58
Selma to Rocky Mt., N. C. (A.C.L. Ry.)	.....	.....	8
Chattanooga, Tenn., to Meridian, Miss.	296.0	393.0	70
Newton to Hickory, N. C. (Car No. West. Eng.)	.....	.....	11
Meridan, Miss., to New Orleans, La.	193.7	206.0	40
Slidell to New Orleans, La. (N.O.G.N. Eng.)	.....	.....	10
Lot to Holton, Ky. (L.&N. Track)	4.6	4.6	4
Austell, Ga., to Birmingham, Ala.	148.4	157.4	75
Haleyville to Jasper, Ala. (Used also by I.C.& M.&O.	40.3	40.3	..
Total	2084.5	2311.3	586
NEW YORK CENTRAL RAILROAD			
Croton to Rensselaer, N. Y.	107.28	316.14	*
Syracuse to Buffalo, N. Y.	147.0	579.79	*
Cleveland, O., to Englewood, Ill.	337.2	987.7	*
Rochester to Suspension Bridge, N. Y.	74.0	148.0	*
Total	665.48	2031.63	*
MICHIGAN CENTRAL RAILROAD			
Niles, Mich., to Kensington, Ill.	78.47	156.94	*
Total New York Central Lines	743.95	2188.57	
CHICAGO & NORTHWESTERN RAILWAY			
Clinton, Iowa, to Chicago, Ill.	137.0	338.0	173
CENTRAL RAILROAD OF NEW JERSEY			
Matawan to Atlantic Highlands, N. J.	11.5	11.5	*

*Engines are listed in tabulation for first and second I.C.C. orders.

Exhibit C

(FIRST ORDER)

INSTALLATION:	Michigan Central Railroad.
DEVICE:	General Railway Signal Company.
FIRST ORDER:	Detroit to Jackson, Mich.
	74.5 miles double track—239 locomotives for both orders.
INSPECTED:	June 16-August 17, 1927.
I.C.C. REPORT:	Decided October 15, 1927 (Sub. No. 37). Opinion 12661.

EXCEPTIONS:

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

Pusher and other locomotives operated backward in road service, with the current of traffic, must be equipped with the train-stop device for such movements.

Non-equipped locomotives must not be operated in train-stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

The integrity of the locomotive circuits must be protected at all times, since certain crosses or grounds could result in false clear failures.

Rate of brake valve reduction should be maintained within the prescribed limits.

It must be known that locomotives passing from unequipped line to equipped territory have their train stop device operative.

Proper relation between the receiver and the rail should be maintained.

Signal circuits should be so arranged that a clear distant signal and clear inductor cannot obtain unless track conditions ahead are clear for the full control of that signal.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

Fouling protection should be provided on crossovers between main tracks.

Consideration should be given the type of fouling protection employed at siding and crossovers with a view of giving increased protection.

Unwound inductors are suggested at certain locations.

INSTALLATION:	Cleveland, Cincinnati, Chicago & St. Louis Railroad.
DEVICE:	General Railway Signal Company.
FIRST ORDER:	Indianapolis, Ind., to Mattoon, Ill.
	55.6 miles single track—70.1 miles double track—111 locomotives.
INSPECTED:	Completed August 20, 1927.
I.C.C. REPORT:	Decided November 22, 1927 (Sub. No. 38). Opinion 12776.

EXCEPTIONS:

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

Pusher and other locomotives operated backward in road service, with the current of traffic, must be equipped with the train-stop device for such movements.

Non-equipped locomotives must not be operated in train-stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Consideration should be given for complete signaling over both tracks for reverse operation to correspond with the method of operation followed.

The integrity of the locomotive circuits must be protected at all times, since certain crosses or grounds could result in false clear failures.

The work of modifying the double heading cocks so as to cut out the engineer's automatic brake valve before the train-stop device should be promptly completed.

Rate of brake valve reduction should be maintained within the prescribed limits.

When receiver coils are removed for repairs, care should be exercised and repairmen should be thoroughly instructed as to testing and handling.

Locomotive relays should be removed when defective and kept sealed while in service.

Electro-pneumatic valves on certain locomotives should be relocated that they may be less exposed to dirt and water.

An inductor should be installed at each signal governing movements from against current of traffic to with the current of traffic.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

It should be determined that the values of the test inductors at terminals are correct.

Dwarf signals used as starting signals at single track interlockings should be controlled as to prevent the possibility of admitting opposing trains to the block.

Circuits at seven interlocked grade crossings should be so arranged to prevent a clear signal while the train occupies the track of the crossing road.

An overlap should be provided for opposing movements for home signals at seven interlockings.

In two situations, the braking distance is insufficient.

Consideration should be given the type of fouling protection employed at siding and crossovers with a view of giving increased protection.

Attention is called to the organizations on other New York Central Lines for maintenance.

INSTALLATION:	Richmond, Fredericksburg & Potomac Railroad.
DEVICE:	Union Switch & Signal Company.
FIRST ORDER:	Richmond to "AF" Block Station, Va.
	101.6 miles double track—75 locomotives.
INSPECTED:	January 16-March 10, 1928.
I.C.C. REPORT:	Decided May 11, 1928 (Sub. No. 39). Opinion 13416.

EXCEPTIONS:

Non-equipped locomotives must not be operated in train-stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided. When locomotives enter train control territory in such a way as to prevent the train control device from automatically cutting in, the locomotive must be cut in when dispatched from the terminal.

REQUIREMENTS:

Train control and air brake equipment should be carefully inspected upon arrival at and before departure from inspection points.

Failures en route should be handled through the dispatcher and investigated.

Time required to make 20-pound brake reduction should be checked.

A systematic program of maintenance of roadside apparatus should be inaugurated.

Effective means should be taken to prevent against stray currents from adjacent tracks.

Certain cut-in circuits should be relocated and installed so as to be effective at a suitable distance, so that the failure of power affecting the cut-in circuits will be checked through the signal and so that a false clear cab signal will not result.

Circuits should be so arranged that a red cab signal will be displayed whenever all absolute stop signals indicate stop.

Circuits should be so arranged that should a roadside signal stand falsely clear, a yellow cab signal with corresponding speed control will be enforced through the block approaching each signal.

Hand thrown derails should be equipped with switch boxes and industrial sidings not so equipped should be provided with derails or switch boxes.

A dead section should be eliminated on a draw bridge.

Arrangements at two interlocked grade crossings should be such as to prevent the display of a clear signal when the crossing track is occupied.

Consideration should be given the type of fouling protection employed at siding and crossovers with a view of giving increased protection.

INSTALLATION: Pittsburgh, Cincinnati, Chicago & St. Louis Railroad.
DEVICE: Union Switch & Signal Company.
FIRST ORDER: Columbus, Ohio, to Indianapolis, Ind.
46.5 miles single track—116.5 miles double track—24.0 miles three track—131 locomotives.

INSPECTED: Completed May 25, 1928.
I.C.C. REPORT: Decided September 19, 1928 (Sub. No. 41).

EXCEPTIONS:

Reset must be prevented from the cab by manipulating the double heading cock and the acknowledging switch.

Pneumatic circuit controller must be on the closed circuit principle.

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

REQUIREMENTS:

Instructions relative to the rate of preliminary exhaust and insuring the brake valve handle must be on lap in order to reset, should be enforced.

The rate of preliminary exhaust should be maintained within proper limits.

The time between the initiation and completion of an automatic brake application must not be sufficient to endanger the established braking distance.

Double heading cocks must have all their ports registering accurately.

INSTALLATION: West Jersey & Seashore Railroad.
DEVICE: Union Switch & Signal Company.
FIRST ORDER: Camden to Atlantic City, N. J.
56.2 miles double track—134 locomotives.

INSPECTED: January 18-April 12, 1928.
I.C.C. REPORT: Decided September 19, 1928 (Sub. No. 40).

EXCEPTIONS:

Non-equipped locomotives must not be operated in train-stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

Reset must be prevented from the cab by manipulating the double heading cock and the acknowledging switch.

Pneumatic circuit controller must be on the closed circuit principle.

REQUIREMENTS:

The time between the initiation and completion of an automatic brake application must not be sufficient to endanger the established braking distance.

A higher degree of supervision should exist at various terminals.

Double heading cocks must have all their ports registering accurately.

The cab signals should be consistent with the indications of roadside signals.

INSTALLATION: New York, New Haven & Hartford Railroad.
DEVICE: Union Switch & Signal Company & General Railway Signal Company.

FIRST ORDER: Air Line Jct. to Springfield, Mass.
59.8 miles double track—60 locomotives.

INSPECTED: June 12—August 20, 1928.
I.C.C. REPORT: Decided September 26, 1928 (Sub. No. 43).

EXCEPTIONS:

Pneumatic circuit controller must be on the closed circuit principle.

REQUIREMENTS:

Double heading cocks must have all their ports registering accurately.
Braking distances should be given consideration.

Exhibit C

(SECOND ORDER)

INSTALLATION: Chicago, Rock Island & Pacific Railway.
DEVICE: Regan Safety Devices Company.
SECOND ORDER: Davenport to Des Moines, Ia.
109.9 miles single track—61.9 miles double track—58 locomotives.

INSPECTED: June 16—July 23, 1927.
I.C.C. REPORT: Decided October 12, 1927 (Sub. No. 1-2). Opinion 12665.

EXCEPTIONS:

None.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Capacity reservoirs missing from certain locomotives should be installed.

All ports in the pneumatic valve of the locomotive should be shown on the plan and should be maintained in standard size.

Improvements should be made in the air brake equipment of the pneumatic portion of the train control.

Engine relay boxes should be kept free from moisture.

Proper use of battery in roundhouses and careful observation of the indicator selector (speed governor) should be required.

Overlaps for certain signals should be checked to insure proper braking distance.

Certain intermediate ramps should be changed to give three indications, and one additional ramp should be provided.

At one junction point, circuits should be changed to insure consistent indications of the ramps and signals.

INSTALLATION: Galveston, Harrisburg & San Antonio Railway.
DEVICE: National Safety Appliance Company.
SECOND ORDER: Glidden to San Antonio, Texas.
119.91 miles single track—21 locomotives.

Inspected: October 17-November 20, 1927.
I.C.C. Report: Decided February 28, 1928 (Sub. No. 4-2). Opinion 13100.

Exceptions:
None.

Requirements:
The requirements as to maintaining forestalling valve, securing adequate braking distance and consideration of type of fouling protection at sidings made in the report on the first installation are called to the attention of the carrier.

Installation: St. Louis-San Francisco Railway.
Device: National Safety Appliance Company.
Second Order: Monett, Mo., to Afton, Okla.
61.2 miles single track—4.9 miles double track—69 locomotives.

Inspected: August 26—September 17, 1927.
I.C.C. Report: Decided November 2, 1927 (Sub. No. 6-2). Opinion 12708.

Exceptions:
None.

Requirements: as to Maintenance, Inspection and Tests.
Forestalling valves to be properly inspected and tested to insure correct timing.
Close attention must be given to gaskets in the forestalling valve.
Consideration should be given to securing greater clearances in the parts of the duplex control valve.
Provide adequate means for preventing scale, dirt, ice, etc., from stopping connections.
Proper height of control valves above the rail must be maintained.
Vigorous supervision of maintenance is necessary.

Installation: Norfolk & Western Railway.
Device: Union Switch & Signal Company.
Second Order: Roanoke to Shenandoah, Va.
132.6 miles single track—44 locomotives.

Inspected: October 11-November 23, 1927.
I.C.C. Report: Decided March 16, 1928 (Sub. No. 7-2). Opinion 13164.

Exceptions:
None.

Requirements:
Arrangements should be made for inspection and test of all engines on arrival at and before departure from inspection and repair point.
All ports and passages should be known to be free from restrictions when apparatus is installed.
The standard rate of reduction through the air brake valve should be maintained.
Speed governor housings on the Chesapeake & Ohio locomotives should be sealed.
Provisions, regarding fouling protection of turnouts, foreign or stray currents and adequate inspections as noted in the first order apply to this also.

Installation: Louisville & Nashville Railroad.
Device: Union Switch & Signal Company.
Second Order: Mobile, Ala., to New Orleans, La.
139.0 miles single track—44 locomotives.

INSPECTED: September 15-October 15, 1927.
I.C.C. REPORT: Decided November 22, 1927 (Sub. No. 14-2). Opinion 12753.

EXCEPTIONS:
None.

REQUIREMENTS: as to Maintenance, Inspection and Tests.

Instructions, reports and records in effect at the time of inspection relative to tests of locomotive and roadway apparatus should be continued.

Vigilance is required in detecting grounds.

Means should be provided to prevent the possibility of neutralizing the device by lowering the train-stop pressure, shutting down the headlight generator or opening the main switch.

Special protection should be provided when train stop device is not operative.

Roadside circuits must be protected to prevent false clear operations.

Further protection should be provided to secure a constant pressure supply.

Longer loops should be used to insure satisfactory recurrent acknowledgment in operation.

A red cab signal indication should be provided between the home signal loop and interlocked switches when such switches are not properly set for the main track.

Circuits should be provided to prevent the display of a clear signal when a crossing train is occupying the track at four specified crossings.

INSTALLATION: Atlantic Coast Line Railroad.
DEVICE: General Railway Signal Company.
SECOND ORDER: S. Rocky Mount, N. C., to Florence, S. C.
172.1 miles single track—135 locomotives for both orders.

INSPECTED: Completed August 5, 1927.
I.C.C. REPORT: Decided September 17, 1927 (Sub. No. 15-2). Opinion 12613.

EXCEPTIONS:

Non-equipped locomotives must not be operated in train-stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

REQUIREMENTS: As to Maintenance, Inspection and Tests.

The work of modifying the double heading cocks so as to cut out the engineer's automatic brake valve before the train-stop device should be promptly completed.

The integrity of the locomotive circuits must be protected at all times, since certain crosses or grounds could result in false clear operations.

Proper relation between the locomotive receiver and rail should be checked and maintained.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

Control circuits should be so arranged as to prevent false clear inductors under certain specified conditions.

Locks or seals should be provided on the locomotive apparatus.

Larger factor of safety would be secured by circuit controllers on all switches and derails not equipped.

INSTALLATION: Atchison, Topeka & Santa Fe Railway.
DEVICE: Union Switch & Signal Company.
SECOND ORDER: Pequot to Chillicothe, Ill.
72.9 miles single track—87 locomotives for both orders.

INSPECTED: Completed December 12, 1927.
I.C.C. REPORT: Decided March 23, 1928 (Sub. No. 18-2). Opinion 13220.

Exceptions:

None.

Requirements:

Care should be exercised to see that the track and loop phases are not overenergized.

It is suggested the desirability of providing circuits at light signals to impose restrictive train control indications in case of the failures of the signals.

Installation:	Baltimore & Ohio Railroad.
Device:	General Railway Signal Company.
Second Order:	Baltimore, Md., to Philadelphia, Pa. 92.5 miles single track—111 locomotives.
Inspected:	November 7-December 14, 1927
I.C.C. Report:	Decided April 25, 1928 (Sub. No. 24-2) Opinion 13353.

Exceptions:

Method of mounting the receiver on one specified locomotive should be changed to a more reliable method.

The reset contactor with a certain type of equipment should be relocated or reconstructed to prevent a release of the brakes before a stop.

Locomotives operating backwards with the current of traffic should be equipped for such movements.

Requirements:

The requirements stated in the report on the first order installation relating to integrity of inductor coils and circuits, protection of tender loop couplers, inspection and tests of locomotives and requirements concerning the operation of non-equipped locomotives are again referred to.

It must be known that locomotives passing from unequipped line to equipped territory have their train-stop device operative.

The work of modifying the double heading cocks so as to cut out the engineer's automatic brake valve before the train stop device should be promptly completed.

The automatic brake valve should be so assembled and maintained that all ports will accurately register when the rotary is moved either manually or automatically.

Necessary details for testing Reading and Central Railroad Company of New Jersey locomotives should be developed.

Portable testing sets used for locomotives should be carefully calibrated for locomotives with Union Switch & Signal Company's equipment.

Proper relation between the receiver and the rail should be maintained.

The integrity of the locomotive circuits must be protected at all times, since certain crosses or grounds could result in false clear failures.

Adjustment of engine relays on the Reading and Central Railroad of New Jersey locomotives should be carefully determined.

Accuracy in voltage on the Reading and Central Railroad of New Jersey locomotives should be carefully followed up.

Proper relationship between the Union Switch & Signal Company receivers and General Railway Signal Company inductors should be brought about.

Written instructions to be furnished signal maintainers for all their work.

Braking distances for certain specified signals should be checked.

Unwound inductors should be provided where clear indication is not required.

Fouling protection should be provided on crossovers between main tracks.

Marker might be used at a certain inductor.

INSTALLATION: Michigan Central Railroad.
DEVICE: General Railway Signal Company.
SECOND ORDER: Jackson to Niles, Mich.
114.96 miles double track—239 locomotives for both orders.

INSPECTED: June 16-August 17, 1927.
I.C.C. REPORT: Decided October 15, 1927 (Sub. No. 37-2). Opinion 12659.

EXCEPTIONS:

Same as stated in first order report.

REQUIREMENTS: As to Maintenance, Inspection and Tests.

The integrity of the locomotive circuits must be protected at all times, since certain crosses or grounds could result in false clear failures.

Rate of brake valve reduction should be maintained within the prescribed limits.

Proper relation between the receiver and the rail should be maintained.

Signal circuits should be so arranged that a clear distant signal and clear inductor cannot obtain unless track conditions ahead are clear for the full control of that signal.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

Fouling protection should be provided on crossovers between main tracks.

Consideration should be given the type of fouling protection employed at siding and crossovers with a view of giving increased protection.

Detector circuits should be installed on the crossing track at two specified towers.

INSTALLATION: Cleveland, Cincinnati, Chicago & St. Louis Railroad.
DEVICE: General Railway Signal Company.
SECOND ORDER: Mattoon to Lenox, Ill.
37.7 miles single track—71.1 miles double track—111 locomotives for both orders.

INSPECTED: Completed August 20, 1927.
I.C.C. REPORT: Decided November 22, 1927 (Sub. No. 38-2). Opinion 12750.

EXCEPTIONS:

Same as stated in first order report.

REQUIREMENTS:

Consideration should be given for complete signaling over both tracks for reverse operation to correspond with the method of operation followed.

The integrity of the locomotive circuits must be protected at all times, since certain crosses or grounds could result in false clear failures.

Rate of brake valve reduction should be maintained within the prescribed limits.

C.&E.I. locomotives should be maintained so as to be safe and suitable for service.

C.&E.I. engine equipments should have the brake valve actuator properly maintained.

Various parts of equipments on C.&E.I. locomotives should be sealed.

The interchangeable cock between the duplicate equipments should be properly sealed on those locomotives where used.

Maintenance of locomotive equipment at a specified location should receive serious consideration.

Test inductors should be installed at one roundhouse.

Inductors should be installed at one specified location for trains coming from the yard.

An inductor should be installed at each signal governing movements from against current of traffic to with the current of traffic.

An inductor should be installed on the C.&E.I. at a specified location.

Inductor should be installed at a signal at a specified location governing movements against traffic.

Dwarf signals used as starting signals at single track interlockings should be controlled as to prevent the possibility of admitting opposing trains to the block.

Control for one specified signal should be such as to give restricting indication should its home signal have been falsely clear.

Braking distance between two specified signals is criticized as being too short.

Braking distance between two specified signals is too short.

No overlap was provided for opposing movements in connection with certain home signals at four locations.

The crossing tracks at two grade crossings should be provided with circuits to prevent a clear signal on the C.C.C.&St.L. when the crossing tracks are occupied.

Section relating to exercising care in testing coils, modifying double heading cock, protecting inductor circuits, considering fouling protection and as to correct values in unwound inductors manufactured by the carrier are the same as in the first order.

INSTALLATION: Pennsylvania Railroad.
DEVICE: Union Switch & Signal Company.
SECOND ORDER: Harrisburg to Altoona, Pa.
12.3 miles double track—6.8 miles three track—111.3 miles four track—354 locomotives.

INSPECTED: January 25-May 5, 1928.
I.C.C. REPORT: Decided September 19, 1928 (Sub. No. 28-2).

EXCEPTIONS:

Non-equipped locomotives must not be operated in train-stop territory, and those with the device cut out must not be run from terminals in such territory, unless double heading behind an equipped locomotive with apparatus in service; locomotives cut out between terminals must have special protection provided.

Reset must be prevented from the cab by manipulating the double heading cock and the acknowledging switch.

Pneumatic circuit controller must be on the closed circuit principle.

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

REQUIREMENTS:

Instructions for tests of locomotive equipment should make certain that the rate of preliminary exhaust is correct, that the brake valve handle must be on lap in order to reset and instructions should be issued to test the pneumatic circuit controller.

The rate of preliminary exhaust should be maintained within proper limits.

Material variation in the timing reservoir pressure should be prevented.

Double heading cocks must have all their ports registering accurately.

Instructions to enginemen should provide for testing the devices to ascertain if an automatic brake application will result when the brake valve is in running position and a restrictive indication of the cab signal is not acknowledged.

Locomotives entering train-stop territory should have their devices tested at entrance to such territory.

Braking distances should be given consideration.

Conditions at certain interlockings which might permit a train to pass the home signal at stop under circumstances which might lead to an accident, must be corrected.

INSTALLATION: Pittsburgh, Cincinnati, Chicago & St. Louis Railroad.
DEVICE: Union Switch & Signal Company.
SECOND ORDER: Pittsburgh, Pa., to Newark, Ohio.
112.49 miles double track—25.89 miles three track—18.03 miles four track.

INSPECTED: January 31-March 31, 1928.
I.C.C. REPORT: Decided September 19, 1928 (Sub. No. 41-2).

EXCEPTIONS:

Reset must be prevented from the cab by manipulating the double heading cock and the acknowledging switch.

Pneumatic circuit controller must be on the closed circuit principle.

The reset contactor must be so located that the brakes cannot be released after an automatic application until the train has stopped.

REQUIREMENTS:

Instructions relative to the rate of preliminary exhaust and insuring the brake valve handle must be on lap in order to reset, should be enforced.

The rate of preliminary exhaust should be maintained within proper limits.

The time between the initiation and completion of an automatic brake application must not be sufficient to endanger the established braking distance.

Double heading cocks must have all their ports registering accurately.

When work is done on the installation, thorough check of the circuits should be made.

Exhibit C

(VOLUNTARY)

INSTALLATION: Michigan Central Railroad.
DEVICE: General Railway Signal Company.
VOLUNTARY INSTALLAION: Niles, Mich., to Kensington, Ill.
78.47 miles double track.

INSPECTED: June 16-August 17, 1927.
I.C.C. REPORT: Decided October 25, 1927 (Sub. No. 37-3). Opinion 12671.

EXCEPTIONS:

Same as stated in first order report.

REQUIREMENTS: As to Maintenance, Inspection and Tests.

The integrity of the locomotive circuits must be protected at all times, since certain crosses or grounds could result in false clear failures.

Rate of brake valve reduction should be maintained within the prescribed limits.

It must be known that locomotives passing from unequipped line to equipped territory have their train-stop device operative.

Proper relation between the receiver and the rail should be maintained.

Signal circuits should be so arranged that a clear distant signal and clear inductor cannot obtain unless track conditions ahead are clear for the full control of that signal.

Installation and maintenance of the track inductor circuit shall be such as to protect the integrity of this circuit against crosses.

Detector circuits should be installed on crossing lines at different points to prevent the display of a clear signal when such tracks are occupied.

Dead sections at six interlockings should be shortened.

Fouling protection should be provided on crossovers between main tracks.

Consideration should be given the type of fouling protection employed at siding and crossovers with a view of giving increased protection.

Appendix B

(3) DEVELOPMENT OF HIGHWAY CROSSING PROTECTION

A. H. Rudd, Chairman, Sub-Committee; T. S. Stevens, J. A. Peabody.

Members of the Committee have had several conferences with members of the Committee on Grade Crossings, and the Chairmen of these Sub-Committees have had considerable correspondence.

Meetings of the American Engineering Council and of the new committee of the American Standards Association Committee on Street Traffic Signs, Signals and Markings have been held and reports prepared for final revision. These reports should issue during the winter.

Therefore, Committee X will present a verbal report at the Annual Meeting in March.

Appendix C

(4) REPORT ON INCREASED EFFICIENCY SECURED IN RAILWAY OPERATION BY SIGNAL INDICATIONS IN LIEU OF TRAIN ORDERS AND TIMETABLE SUPERIORITIES

W. J. Eck, Chairman, Sub-Committee; F. W. Pfleging, W. M. Post.

Train operation by signal indication was first put into successful use in 1882 on the Pennsylvania Railroad at Louisville, Ky. This method of directing train movement, therefore, is not new in principle. The Louisville installation led to a similar one in 1889 on the Nashville, Chattanooga & St. Louis Railway, near Chattanooga, Tenn. In both of these installations train movements were directed by signal indications given under the instructions of the dispatchers and without the use of written train orders.

It was not until 1907, however, that this method of operation received substantial recognition, following an installation made on a single-track line in which track circuits, for controlling the manually operated signals, fully established the efficiency and reliability of the method as a means for directing train movements without train orders on single-track lines.

This installation was soon followed by many others so that today over 100 installations have been made on thirty-one railroads in this country and Canada with a total of 1763 track miles, consisting of 613 miles of single track and 1150 miles of multiple-track lines for "either-direction" operation, for directing train movements by signal indication without the use of train orders.

This mileage represents lines on which, with but few exceptions, there is heavy traffic movement and more than ordinary demand upon track capacity. In many of the installations the greater capacity provided by this efficient method of operation postponed the necessity for building and maintaining many miles of additional track, thus effecting substantial savings in both construction and maintenance costs.

In the past two years a greatly improved system of train operation by signal indication has been developed. The new system simplifies the work of the train dispatcher and enables him to increase substantially the output of transportation, especially on single-track lines.

In this new system, the signals and switches of a district are operated and controlled from a central point by a dispatcher solely by the use of electrically operated signaling devices and without the aid of operators. The dispatcher directs the movement of trains by operating the signals whose indications authorize the movement. By direct operation of the switches as well as the signals, the train dispatcher also sets up the routes as required. Through the elimination of the task of issuing written train orders, the dispatcher can concentrate all of his efforts on keeping trains moving with minimum delay and thus assure a maximum utilization of trackage and equipment together with a greatly reduced accident hazard.

THE THREE METHODS OF DIRECTING TRAIN MOVEMENTS

Before giving further consideration to train operation by signal indication, a brief review of the methods of directing train movements should be made.

On the railroads of the United States three methods of directing train movements are in use:

(1) **By Timetables and Train Orders**—the *time* interval method.

The Standard Code of the American Railway Association defines a timetable as:

> "The authority for the movement of regular trains subject to the rules. It contains a classified schedule of trains with special instructions relating thereto."

The Code rule for use of train orders is:

> "For movements not provided for by timetable, train orders will be issued by authority and over the signature of the Superintendent. * * *" (Rule 201).

Prior to the use of the telegraph in train operation, the timetable was the sole authority for train movements. Had it been possible to run all trains in exact accordance with the timetable, operation of trains would have been a comparatively simple matter. It was not possible, even in the early days when traffic was light, to avoid serious delays to trains. The use of the telegraph, for authorizing movements not provided for by the timetable, made it possible for the first time to transport passengers and freight without intolerable delays.

In the time interval method of directing train movements the safety of train operation is dependent upon the exact observance of the many rules governing train operation, particularly those governing train orders; the special instructions in the timetables and the protection by flagging and otherwise; as well as upon exact synchronism of the watches or clocks used by dispatchers, operators, enginemen, conductors and others having to do with train movement.

Protection against head-end collisions on single track is dependent upon the observance of timetable and train order instructions as to meeting points.

Protection against rear-end collisions on single and multiple tracks is provided for by the flagging rule.

(2) By Timetables, Train Orders and Block Signals—a *space* interval method.

This method is identical with the one just described, except that the use of the block signal provides a method of maintaining a space interval between trains as a further protection against head-end and rear-end collisions.

(3) By Signal Indication—a *space* interval method.

In this method of operation, the indications of the signals govern train movements, as set forth in the Standard Code rule as follows:

> "Controlled manual block signals govern the use of blocks and unless otherwise provided their indications supersede timetable superiority and take the place of train orders * * * ." (Rule C-305.)

A recent ruling by the Operating Division of the A.R.A. is a further recognition of this method of directing train movements by signal indications. This ruling is as follows:

> "Where the movements are fully protected by signaling devices the full utilization of the track systems [track facilities] should be taken advantage of and that in the absence of such signaling, operation should be conducted by train orders."

This ruling means, in other words, that where an adequate signaling system provides signals that can be used in directing train movements, the indications of these signals will be the sole authority for these movements. Train orders will then be unnecessary except in cases where the instructions are of such a character that they cannot be given by signal indications.

DEVELOPMENT OF TRAIN OPERATION BY SIGNAL INDICATION ON SINGLE-TRACK LINES

The first installation of train operation by signal indication, as previously stated, was made in 1882 on the Pennsylvania Railroad at Louisville, Ky. At that time the line entering Louisville over the Louisville Bridge crossing the Ohio River was single track. Trains of the four roads using the bridge totaled 150 daily. As Standard Time had not come into use, trains were scheduled on the local time of the four roads, each one with a different time standard. This time difference made it practically impossible to operate trains by timetables and train orders, as any *time* interval method requires a single standard of time.

To meet this unusual situation the space interval method was put into use by the installation on the eight miles of line of six manual block sections.

The block signals were made the sole authority for directing train movements.

This was undoubtedly the first installation on a single track line of train operation by signal indication. This installation has this year (1929) made a record of forty-seven years of successful operation.

This record is no doubt due to certain distinctive features of the installation which, while they were comparatively new in 1882, are today recognized as essentials in the operation of trains by signal indication.

The distinctive features of the Louisville installation are:

(1) The use of the space interval or block signal method.

(2) The operation of the trains through the block sections controlled from a central point by a dispatcher in charge of the territory directing the movement of trains through instructions issued by him to the operators at the six block stations.

In the advance in the art of railway signaling the recent installations have placed the dispatcher in *direct* control of signals and switches, thus dispensing with the operators.

(3) The "mnemonic" board used by the dispatcher as an aid in visualizing the movement of trains. Each train is represented by a peg and these pegs are moved by the dispatcher from hole to hole on the board to represent the movement of trains through the different block sections.

This "hand-operated" train movement board (still in use) was the forerunner of the now highly perfected automatic train graphs, which not only show the location of trains at any moment but continuously record their movement.

To sum up, the successful operation of the Louisville Bridge installation is due to (a) the use of a block system in which the signals are the sole authority for train movements; (b) a central control of these signals by the dispatcher (through the operators); (c) the timetable serving only as a program for the daily train movements, and conveying no authority for their movement; and (d) the elimination of train orders.

The Louisville installation led to a similar one in 1889 on the Nashville, Chattanooga & St. Louis Railway near Chattanooga, Tenn., covering 4.4 miles of single track and 1.6 miles of double track, divided into three manual block sections, all operated under the instructions of the dispatcher at Chattanooga. This installation remained in use until 1912 when the line was double-tracked. The total movement in the twenty-four years on the single track section was over one-half million trains, with a one hundred per cent safety record.

Assuming that without the use of the system, or the construction of another running track, trains could not have been operated safely from 1889 to 1912, this installation should be credited also with the savings in maintenance, taxes and interest charges on the second track during the twenty-four years the double-track construction was postponed.

The fifth installation was made in 1907 by the Pennsylvania Railroad near Huntley, Pa., covering 8.6 miles of single track divided into two block sections.

This installation employed the track circuit controlled manual principle of blocking. In that respect it differs from the two earlier installations, previously described, which used the manual block system without the track circuit.

Train movements are directed by the block signal operators under the supervision of the dispatcher. This installation now (1929) has a record of twenty-two years of successful service.

The seventh installation, made in 1909 on the Central New England Railway between Highland and Maybrook, N. Y., covered 13.2 miles of single track and 7 miles of double track, divided into nine controlled manual block sections with track circuits. Train movements were made without train orders under a very simple rule:

> "Electric signals will govern train movements on single track within these limits regardless of timetable rights."

The daily traffic averaged 44 trains. As traffic capacity was increased 25 per cent, it was possible to postpone double-tracking for five years.

The net savings in interest and maintenance charges (exclusive of any savings in train operating expense) due to postponing the construction of a second main track were equivalent to forty-four per cent of the total cost of the second track. This system not only paid its way in train operation economies but helped to pay for the double track which finally became necessary because of continuing increases in traffic.

The fourteenth installation and the second on the Nashville, Chattanooga & St. Louis Railway was made in 1911 between Cowan and Sherwood, Tenn. This installation covered 11 miles of single track, divided into four controlled manual block sections. On account of heavy curvature and a two per cent grade over the Cumberland Mountains, this 11-mile district was the "bottle neck" of the division.

These five installations were pioneers in train operation by signal indication on single track lines. Three are still in use (1929): Two on the Pennsylvania Railroad (Louisville, Ky., and Huntley, Pa.), and one on the Nashville, Chattanooga & St. Louis at Cowan-Sherwood, Tenn. They have made a combined record of eighty-seven years of service.

The two installations taken out of service, one on the Nashville, Chattanooga & St. Louis at Chattanooga, Tenn., and the other on the Central New England at Highland-Maybrook, New York, made a combined record of thirty-four years of service before increasing traffic necessitated double tracking.

Substantial progress has been made since these pioneer installations were put into use. As evidence of this progress, a list has been compiled of the installations made for the purpose of directing train movements by signal indication. (See page 535.)

DEVELOPMENT OF TRAIN OPERATION BY SIGNAL INDICATION ON MULTIPLE-TRACK LINES

Train operation by signal indication without train orders on multiple-track lines *with* the current of traffic was in use as early as 1890-91 on the New York Division (four-track line) of the Pennsylvania Railroad. The American Railway Association officially recognized this method of operation in 1903 and *against* the current of traffic, "either direction" operation on double track, by means of block signals, in 1904.

The problem as stated by the Association in 1903, as follows:

> "The term 'operation without train orders' is, of course, something of a misnomer. The system contemplates rather a change in the manner of delivering orders [by signal indications], the method of working under them and by relief of the engine and train crews from the frequent necessity of performing more or less complicated arithmetical problems in order to determine exactly what their orders are. With a train scheduled at a certain time for every station on a division and with an order requiring it to run one hour and thirty minutes late from a certain point, the possibilities of error in the calculation of time are large. The fact also that freight trains are required to keep out of the way of trains of a superior class running in the same direction involves either undesirable delays in waiting at passing stations or the taking of long chances in getting to the next passing point * * * ."

Today it is common practice on multiple-track lines to govern the movement of trains with the current of traffic by block signals.

A notable step in this direction was made by the Erie Railroad in 1910 on its double-track divisions by the use at non-interlocked switches of signals giving three indications: "hold main," "take siding" and "stop." These signals were used by the train dispatcher in directing train movements by sending to the operators directly controlling the signals telephone instructions as to the indications to be displayed. Through the use of these signals on the important divisions of the Erie Railroad, train orders were practically eliminated.

COMPARISON OF THE THREE METHODS OF DIRECTING THE MOVEMENTS OF TRAINS

The three methods of directing the movements of trains as previously described are:

(a) By timetable and train orders.
(b) By timetable, train orders and block signals.
(c) By signal indications.

In the two methods that use timetables and train orders, the train order plays the leading part, particularly in directing train movements on single track. It is estimated that some 5000 train dispatchers on the roads of the United States issue for directing train movements, no less than 130,000 train orders daily, or close to fifty million train orders annually.

The difference between train orders and signal indications as a means for directing train movements may be summed up as follows:

Train orders are written instructions that must be delivered to the conductor and engineman of the train. They must be correctly prepared, transmitted, delivered and understood. *They must not be forgotten.* On roads *not* equipped with modern signaling systems, safety of operation depends entirely upon the human element, for there is no check either electrical or mechanical to prevent an improper train movement should an error occur in the preparation, transmittal or delivery of the order, or should the order be misunderstood or forgotten.

In directing the movement of trains by train orders, seven standard forms are used for the following purposes:

For fixing meeting points.
For directing a train to pass or run ahead of another train.
For giving right over an opposing train.
For authorizing a train to run late (time order).
For holding trains.
For directing a movement against the current of traffic.
For authorizing the use of a section of double track as a single track.

Signal indications, on the other hand, are simplified instructions for directing the movement of trains given by the aspects of fixed roadside or cab signals. As signal aspects are few in number, there is but little opportunity for misunderstanding their indications.

The train order calls for deferred action, whereas the signal indication, conveynig instructions at the points where they are to be executed, calls for immediate action. Hence there is no lapse of time in which to forget the instructions. The signal indication is a "do-it-now" order.

Operation by train orders requires delivery of the order to the train. If in motion, the train must slacken speed or stop to receive the train order instructions as to how it should proceed. As train orders are for the ultimate purpose of keeping trains moving, this slowing down or stopping for the delivery of orders in a measure defeats this purpose. The signal indication method on the contrary does not require the train to stop for proceed instructions.

The train order method when it retards the movement of trains causes loss of time. Delayed trains unnecessarily obstruct the tracks they occupy. Delayed trains reduce the output of transportation and increase train costs. To produce transportation, trains must be kept moving; hence the train order method when it unnecessarily retards or stops the movement of trains tends to limit the production of transportation.

In directing train movements by signal indication, two types of signals are used:

(a) Interlocking signals that govern and are the authority for the use of the routes of an interlocking plant.

An interlocking plant at a large terminal through which train movements are made under the direction of the train director and by authority of the interlocking signals is a fine example of train operation by signal indication.

The hundreds of interlocking plants in use today are ample proof of their reliability and efficiency.

(b) Controlled manual block signals that govern and are the authority for the use of the blocks. Their indications supersede timetable superiority and take the place of train orders.

NOTE.—Interlocking signals are also used in controlled manual block systems both as interlocking and as block signals.

The installations for the operation of trains by signal indication, described in this report, are for two purposes:

(a) For operation on single-track lines.
(b) For "either-direction" operation on one or more tracks of multiple-track lines.

All of the installations described with the exception of the two made prior to 1907 are, in effect, controlled manual block systems with all the safeguards inherent in such systems.

The installations of train operation by signal indication are operated in two ways:

(a) The method generally in use is one in which the control of the signals is directly in the hands of the signalmen or operators, working under the general direction of the train dispatcher through telephone instructions.

(b) The other and latest method is one in which the dispatcher directly controls and operates both signals and switches on the line without recourse to operators, and has before him a visual indication of the location of trains at any moment as well as a graphic record of their previous movements.

Two notable installations of the dispatcher control type have been put in use on single-track lines; one on July 25, 1927, on the New York Central between Toledo and Berwick, Ohio, forty miles; and one on July 1, 1928, on the Pere Marquette between Mount Morris and Bridgeport, Mich., twenty miles. These two installations represent the very latest development in train operation by signal indication, in which the signals are directly controlled from a central point by a train dispatcher who directs all train movements by signal indication without the use of train orders and in addition operates the switches at the passing sidings.

With the present development of the art of signaling, the direction of train movement by signal indication, without the use of written train orders, is in every detail simple and feasible. The methods employed in the installations described in this report have met with the approval of the most conservative railway authorities.

ECONOMIC ADVANTAGES OF TRAIN OPERATION BY SIGNAL INDICATION

(1) Delays Are Reduced

A train order, ordinarily prepared on estimates of future performance, takes into account the movements to be made during an hour or more (often several hours) after the order is issued. Failure by the superior train to meet the expected performance ties up the inferior train. Because the train order system requires so much time it is not always possible to afford relief to the inferior train by new orders and substantial delays are unavoidable. Under operation by signals no time is required to change the lineup. The dispatcher can operate from minute to minute instead of from hour to hour.

By directing train movements by signal indications in place of by train orders, slow-downs or stops for orders are eliminated and trains are kept moving.

When passing siding or other switches are operated by interlocking or by remote power switch machines, the train stops to throw switches are eliminated and trains are kept moving.

(2) Track Capacity Is Increased

When delays are reduced and trains kept moving, track capacity is increased.

When capacity of single-track lines is increased, double tracking (often prohibitive in cost) can be postponed.

When the capacity of two or more track lines is increased by "either-direction" operation, the construction of additional main tracks can often be postponed.

Note.—For roads reporting installations that have substantially increased track capacity, see list of installations of Train Operation by Signal Indication, page 535.

(3) Safety Is Increased

Train operation by signal indication provides operating facilities that greatly reduce operating hazards.

These facilities are:

(a) Automatic and controlled manual block signal protection.

(b) Dispatcher or operator control of the signals in use at points where it is necessary to direct or authorize train movements (e.g., at passing siding switches, ends of double track, junctions, crossovers, etc.)

(c) Dispatcher or operator control of switches (those in frequent use) by interlocking or by remote power switch machines.

(d) Automatic train movement board for visualizing the location of trains at any moment or indicators for announcing the trains, thus giving the dispatcher or operator the necessary "OS" information for each train. (A development of the "mnemonic" board used in the Louisville installation in 1882.)*

(e) Central control of the system by which the dispatcher directs the movement of trains by signal indication without the use of train orders.

This central control is of two kinds:

> Where the dispatcher directs train movements by telephone instructions to the operators directly in control of the signals and the switches.
>
> Where the dispatcher directs train movements by *directly* controlling and operating the signals and the switches.

*Note.—Graphic train charts for visualizing train movement records are extensively used by many foreign railways. See Train Operation by Signal Indication, Bulletin 3, by H. M. Sperry, New York.

Train operation by signal indication further promotes safety by reducing train delay. (It has been well said that a standing train is a liability.) When train delay is decreased and trains kept moving, safety is increased.

(4) Freight Train Operating Costs Are Reduced

Operating costs are reduced when delays are reduced.

When freight train delay is reduced by eliminating unnecessary stops the average train speed between terminals is increased without increasing the speed while in motion. Average speed increased in this way tends to decrease train hours, crew overtime and fuel consumption and to increase track capacity.

When train hours are decreased the time saved is a measure of the increased efficiency of the transportation machine. This increased efficiency means that less labor and fewer cars and locomotives will be required to produce a given output of ton-miles, thus reducing the cost of operation.

Increased track capacity postpones the need for additional main tracks. The records of many of the installations of train operation by signal indication show that heavy expenditures for additional main tracks were postponed, effecting large savings in operating, maintenance and interest charges.

In giving consideration to the economies to be effected by train operation by signal indication, the cost of installation must be balanced against the estimated savings. The result may or may not justify the installation. The successful operation of our roads by timetables, train orders and block signals should also be taken into account and the cost of train operation under this system weighed against the cost of train operation by signal indication. The economic advantages of one system over the other should determine the system to be used.

One collateral advantage should not be overlooked. Much has been said recently about the improvement in the quality of railway freight service from the viewpoint of the shipping public. That service is now more expeditious and more dependable than ever before. To that result the greater use of modern signaling has contributed in substantial part. Further reductions in avoidable train delays will bring further improvements in public transportation service.

The operating records made by the installations of train operation by signal indication now covering 1703 track miles, show substantial economic advantages through a reduction in train delays: an increase in ton-miles per train-hour; a decrease in ton-mile costs and what is most important, an increase in safety.

Economics of Railway Operation

TABLE I—TRAIN OPERATION BY SIGNAL INDICATION WITHOUT THE USE OF WRITTEN TRAIN ORDERS

List of Installations on the railways of the United States and Canada for train operation by signal indication on single-track lines and for "either-direction" operation on one or more tracks of multiple-track lines.

The installations for the purpose of directing train movements by the indications of fixed or cab signals are of two types:

(a) Installations in which the operators directly control the signals and switches and direct the train movement under telephone instructions of the dispatcher.

(b) Installations in which the dispatcher directly controls the signals and switches and without the aid of operators, directs the train movement (central control system).

"Either-direction" operation within interlocking territory as in large terminals and normal direction operation on multiple tracks are not included in this list.

The list arranged in chronological order includes all installations (as far as it has been possible to obtain the records) that have been made on the railroads of the United States and Canada since the first installation in 1882. All the installations with three exceptions are still in use.

All but three installations are in effect controlled manual block systems with all the safeguards inherent in such systems, such as traffic locking, semi-automatic signals, etc. The three exceptions are manual block systems and are so noted.

Table I—Train Operation by Signal Indication

Summary of Installations

(Listed on pages 23c-23m)

	Road	Miles of Road: Single Track	Double Track	Three Track	Four Track	Total	Miles of Track Total
1	A. T. & S. F.	18.	175.7			193.7	369.4
2	A. C. L.	18.1	1.1			19.2	20.3
3	B. & O.	111.7	1.7	31.9	5.6	150.9	152.6
4	B. & M.	1.	18.	1.5		20.5	41.5
5	C. P.	9.				9.	9.
6	C. of Ga.	28.1				28.1	28.1
7	C. R. R. of N. J.			2.4	12.0	14.4	23.1
8	C. & O.	6.	33.	3.3	1.	43.3	85.9
9	C. & N. W.			14.		14.	14.
10	C. B. & Q.	19.	47.	34.		100.	147.
11	C. R. I. & P.		24.	3.1	6.6	33.7	64.3
12	C. C. C. & St. L.	90.				90.	90.
13	D. & H.	6.				6.	6.
14	D. L. & W.	2.9	1.	14.8	1.9	20.6	27.5
15	D. & R. G. W.	3.				3.	3.
16	Erie	15.7	3.6		2.2	21.5	31.7
17	I. C.		20.	26.	6.	52.	72.
18	L. I.	11.				11.	11.
19	L. N.	5.4				5.4	5.4
20	M-K-T	5.				5.	5.
21	M. P.	50.1	5.9			56.	61.9
22	N. C. & St. L.	15.4	4.1			19.5	23.6
23	N. Y. C.	37.	4.1		20.3	61.4	65.5
24	N. Y. N. H. & H.	15.5	7.		1.6	24.1	33.9
25	N. Y. O. & W.	2.3				2.3	2.3
26	P. R. R.	66.9	25.3	16.1	11.2	119.5	144.8
27	P. M.	20.				20.	20.
28	P. & R.	25.				25.	25.
29	St. L.-S. F.	9.5	4.7			14.2	18.9
30	T. & P.	11.	69.			80.	149.
31.	W. M.	11.				11.	11.
	Totals	613.6	445.2	147.1	68.4	1274.3	1762.7

Totals

	Miles of Road	*Miles of Track*
Single-track operation	613.6	613.6
"Either-direction" operation:		
Double-track	445.2	890.4
Three-track	147.1	162.6
Four-track	68.4	96.1
Totals	1274.3	1762.7

Table I—Installations of Train Operation By Signal Indication—Continued

No.	Year	Road and Location	Miles of Road			
			Single Track	Double Track	Three Track	Four Track
1	1882	PENNSYLVANIA Louisville Bridge, Louisville, Ky. Manual block. Central control.......	5.5	2.5		
2	1883	BOSTON & MAINE Salem Tunnel, Mass.................	1.			
3	1888	CHICAGO, BURLINGTON & QUINCY Chicago to Aurora, Ill. Either direction middle track			34.	
4	1889	NASHVILLE, CHATTANOOGA & ST. LOUIS Chattanooga, Tenn. Manual block. Replaced by double track in 1912......	4.4	1.6		
5	1907	PENNSYLVANIA Huntley to Cameron, Pa.............	5.	3.5		
6	1908	BALTIMORE & OHIO Brook to Confluence, Pa.............	4.4			
7	1909	CENTRAL NEW ENGLAND (now a part of the New York, New Haven & Hartford) Highland to Maybrook, N. Y. Replaced by double track in 1914........	13.2	7.		
8	1910	ATLANTIC COAST LINE Peedee, S. C. Changed to gauntlet, 1925	2.3			
9	1910	LONG ISLAND Locust Valley to Oyster Bay, N. Y..	4.			
10	1910	PENNSYLVANIA Pennsylvania Station, New York City, "JO" Cabin to Thompson Avenue, New York East River Tunnel).......			3.0	
11	1910	PENNSYLVANIA Pennsylvania Station, New York City, "C" Cabin to Thompson Avenue, New York East River Tunnel)............			3.0	
12	1910	PENNSYLVANIA Pennsylvania Station, New York City, to Manhattan Transfer, N. J. (Hudson River tunnels).................		8.3		
13	1910	ERIE Jersey City to Croxton, N. J. Either direction all tracks..................				2.2
14	1911	NASHVILLE, CHATTANOOGA & ST. LOUIS Cowan to Sherwood, Tenn...........	11.	2.5		
15	1911	BALTIMORE & OHIO Millers, O., to Orleans Road, W. Va. Either direction one track...........			19.4	5.6
16	1912	ATCHISON, TOPEKA & SANTA FE Bee Creek Junction to St. Joseph, Mo. Manual block. Originally staff system.	10.			
17	1912	BALTIMORE & OHIO "Q" to "DA" Towers (Ohio Division), Ohio	1.1			

TABLE I—INSTALLATIONS OF TRAIN OPERATION BY SIGNAL INDICATION—Continued

No.	Year	Road and Location	Miles of Road Single Track	 Double Track	 Three Track	 Four Track
18	1912	BALTIMORE & OHIO Glenwood Junction to Rand, Pa......	2.5			
19	1912	BALTIMORE & OHIO Powell to Kingmont, W. Va..........	7.3			
20	1912	NEW YORK, NEW HAVEN & HARTFORD Barrington to North Warren, R. I. Gauntlet track over two bridges.......	.4			
21	1912	PENNSYLVANIA Wolverton to South Danville, Pa....	4.2			
22	1913	ATLANTIC COAST LINE North Tower (Southover) to Georgia Junction, Ga.		1.1		
23	1913	ATLANTIC COAST LINE Weldon, N. C. Gauntlet.............	1.2			
24	1913	PENNSYLVANIA New Castle to Fayne, Indiana........	2.4			
25	1913	PENNSYLVANIA Spruce Creek to Tyrone Forge, Pa. Either direction middle track.........			7.0	
26	1913	PHILADELPHIA & READING Carlisle Junction to Gettysburg, Pa. In use 16 days for heavy passenger traffic 50 Anniversary Battle of Gettysburg	25.			
27	1913	NEW YORK, NEW HAVEN & HARTFORD Worcester to South Worcester, Mass. Either direction four tracks..........				.6
28	1914	ATLANTIC COAST LINE Dunlop to Collier, Va. (Petersburg Belt Line)	5.8			
29	1914	ATLANTIC COAST LINE St. Stephens to Santee, S. C.........	3.2			
30	1914	BALTIMORE & OHIO Benwood Loop (Wheeling Division).	.7			
31	1914	BALTIMORE & OHIO Sand Patch to Manila, Pa............		1.7		
32	1914	BALTIMORE & OHIO Okonoko to Patterson Creek, W. Va. Either direction one track............			12.5	
33	1914	ERIE Pymatuning to Sharpsville, Pa.......	5.0			
34	1914	ERIE Hubbard, O., to Coles, Pa...........	9.2			
35	1914	PENNSYLVANIA Mt. Eagle to Howard, Pa............		5.0		
36	1915	PENNSYLVANIA Eldorado to New Portage Junction, Pa.	3.3			
37	1916	BALTIMORE & OHIO Pennsylvania Junction to Lake Shore Junction, O.	.6			

Table I—Installations of Train Operation By Signal Indication—Continued

No.	Year	Road and Location	Miles of Road: Single Track	Double Track	Three Track	Four Track
38	1916	St. Louis-San Francisco Birmingham, Ala.	1.			
39	1916	Western Maryland Cumberland (MY Block) to North Branch, Md.	4.			
40	1916	Western Maryland Williamsport to Clearspring, Md.	7.			
41	1916	Chicago, Burlington & Quincy Aurora to Mendota, Ill.		47.		
42	1916	Pennsylvania Davis to Ragan, Del. Either direction middle track			9.1	
43	1916	Pennsylvania South Fork to Sheridan, Pa. Either direction one track				11.2
44	1917	Baltimore & Ohio Butler to Standard Junction, Pa.	.4			
45	1918	Baltimore & Ohio Piqua to Kirkwood, O.	5.2			
46	1918	Erie Riverside to North Hawthorne, N. J.	1.5			
47	1918	New York, New Haven & Hartford East Hartford, Conn. Gauntlet track over bridge	.5			
48	1918	New York, New Haven & Hartford Poughkeepsie Bridge, N. Y. Gauntlet track over bridge	1.4			
49	1919	Chesapeake & Ohio Cotton Hill to Gauley, W. Va.	4.			
50	1919	Louisville & Nashville "FS" Tower, Ind., to Henderson, Ky.	4.6			
51	1922	Delaware, Lackawanna & Western Denville to East Dover Junction, N. J.	2.9			
52	1922	Delaware, Lackawanna & Western "BY" to "RD" Tower, Binghamton, N. Y.		1.		
53	1922	Delaware, Lackawanna & Western West End to Newark, N. J. Either direction two tracks			5.9	
54	1922	Delaware, Lackawanna & Western Newark to Milburn, N. J. Either direction one track			8.9	
55	1922	Delaware, Lackawanna & Western Hoboken to West End, N. J. .7 mile in five track territory. Either direction four tracks				1.9
56	1923	Atlantic Coast Line Doctortown to Back Swamp, Ga.	3.			
57	1923	Chesapeake & Ohio Clyffeside to West Ashland, Ky.		4.		

TABLE I—INSTALLATIONS OF TRAIN OPERATION BY SIGNAL INDICATION—Continued

No.	Year	Road and Location	Miles of Road: Single Track	Double Track	Three Track	Four Track
58	1923	CHESAPEAKE & OHIO Scott to "DK" Cabin, W. Va........		28.		
59	1924	ATLANTIC COAST LINE Chatham, Ga., to Sand Island, S. C. (Savannah River)	2.6			
60	1924	CENTRAL OF GEORGIA Macon to Paynes, Ga..............	4.5			
61	1924	ILLINOIS CENTRAL Otto to Gilman, Ill.................		20.		
62	1924	GULF, COLORADO & SANTA FE (Atchison, Topeka & Santa Fe Ry. System) Fort Worth to Saginaw, Texas. Heavy switching movement	8.			
63	1924	LOUISVILLE & NASHVILLE Dolen to North Hazard, Ky.........	.8			
64	1924	ERIE Croxton to Hackensack River, N. J...		3.6		
65	1924	NEW YORK CENTRAL Grand Central Terminal to Mott Haven, N. Y. Either direction track No. 4				5.
66	1925	CHICAGO, BURLINGTON & QUINCY Pacific Junction to Plattsmouth, Neb.	5.			
67	1925	CHICAGO, BURLINGTON & QUINCY Greenwood to Waverly, Neb.........	7.			
68	1925	MISSOURI-KANSAS-TEXAS Muskogee to Wybark, Okla..........	5.			
69	1925	MISSOURI PACIFIC Kansas City to Osawatomie, Mo. Includes train control..................	50.1	5.9		
70	1925	CHESAPEAKE & OHIO West Ashland to Russell, Ky. Either direction all three tracks............			3.3	
71	1925	CHICAGO & NORTHWESTERN Elmhurst to West Chicago, Ill. Either direction middle track..............			14.	
72	1925	ILLINOIS CENTRAL Otto to Monee, Ill. Either direction middle track			26.	
73	1925	NEW YORK, NEW HAVEN & HARTFORD New Haven Station to Cedar Hill, Conn. Either direction two tracks....				1.
74	1926	LONG ISLAND Whitestone Junction to Whitestone Landing, N. Y.....................	3.			
75	1926	LONG ISLAND Great Neck to Port Washington, N. Y.	4.			
76	1926	CHICAGO, ROCK ISLAND & PACIFIC Chicago Terminal, 60th to 86th St., Ill. Either direction one track........			3.1	

TABLE I—INSTALLATIONS OF TRAIN OPERATION BY SIGNAL INDICATION—Continued

No.	Year	Road and Location	Miles of Road — Single Track	Double Track	Three Track	Four Track
77	1926	{ CHICAGO, ROCK ISLAND & PACIFIC / NEW YORK CENTRAL } Chicago Terminal, Ill. (4 and 6 tracks). Either direction tracks Nos. 2 and 5				6.6
78	1926	CENTRAL RAILROAD OF NEW JERSEY "BV" Tower Bayonne, to "FH" Tower, Elizabethport, N. J. (Four track draw.) Either direction all tracks				2.9
79	1926	ILLINOIS CENTRAL Chicago Terminal, Ill. (8 tracks.) Either direction track No. 1				6.
80	1927	CENTRAL OF GEORGIA Terra Cotta to Carman, Ga	23.6			
81	1927	DELAWARE & HUDSON Cooperville to Rouses Point, N. Y. Also 3 miles of running track adjacent to the single track line	6.			
82	1927	PENNSYLVANIA Henry to Gem, Indiana	16.3			
83	1927	PENNSYLVANIA Bradford to New Paris, O	30.2			
84	1927	NEW YORK CENTRAL (Ohio Central Lines) Stanley (Toledo) to Berwick, O. Central control	37.	3.		
85	1927	NEW YORK CENTRAL Weehawken to New Durham, N. J. (Weehawken tunnel)		1.1		
86	1927	NEW YORK CENTRAL New Durham to Little Ferry, N. J. Either direction track No. 3				4.6
87	1927	ATCHISON, TOPEKA & SANTA FE Fort Madison, Iowa, to Pequot, Ill. Includes cab signals and train control.		175.7		
88	1927	CHICAGO, ROCK ISLAND & PACIFIC Blue Island to Joliet, Ill. Either direction one track		24.		
89	1928	CANADIAN PACIFIC Medicine Hat to Dunmore, Alberta, Canada	9.			
90	1928	CHICAGO, BURLINGTON & QUINCY West Quincy, Mo	7.			
91	1928	PERE MARQUETTE Mt. Morris to Bridgeport, Mich. Central control	20.			
92	1928	ST. LOUIS-SAN FRANCISCO Harvard to Bridge Junction, Ark	4.8	4.7		
93	1928	ST. LOUIS-SAN FRANCISCO Nichols to Springfield, Mo	3.7			

TABLE I—INSTALLATIONS OF TRAIN OPERATION BY SIGNAL INDICATION—Continued

No.	Year	Road and Location	Miles of Road Single Track	Double Track	Three Track	Four Track
94	1928	CENTRAL RAILROAD OF NEW JERSEY "JU" Tower, Bethlehem Junction to "VN" Tower, Rittersville, Pa. Either direction one track			2.4	
95	1928	CENTRAL RAILROAD OF NEW JERSEY Aldene to "QR" Tower, Lorraine, N. J. Five track territory; either direction one track				2.5
96	1928	CENTRAL RAILROAD OF NEW JERSEY "A" Tower, Jersey City to "BV" Tower, Bayonne, N. J. Either direction one track				6.6
		INSTALLATIONS UNDER CONSTRUCTION				
97	1928	BALTIMORE & OHIO Grafton to Parkersburg, W. Va.	89.5			
98	1928	BOSTON & MAINE Hoosac Tunnel to North Adams Station, Mass. Either direction all tracks.		5.	1.5	
99	1928	BOSTON & MAINE North Chelmsford to Ayer, Mass. Central control		13.		
100	1928	CHESAPEAKE & OHIO Cheviot, Ohio	2.			
101	1928	CHESAPEAKE & OHIO Covington, Ky. Either direction all tracks		1.		1.
102	1928	CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS Terre Haute, Ind., to Pana, Ill.	90.			
103	1928	DENVER & RIO GRANDE WESTERN Tennessee Pass, Colo. (Rocky Mountains) 20 miles of double track normal direction only not included	3.			
104	1928	NEW YORK CENTRAL Palmyra to Wayneport, N. Y. Either direction on track No. 1. Train control.				10.7
105	1928	NEW YORK, ONTARIO & WESTERN Fulton, N. Y.	2.3			
106	1928	TEXAS & PACIFIC Dallas to Fort Worth, Texas. Central control	10.	20.		
107	1928	TEXAS & PACIFIC Addis to Johnson, La. Central control.	1.	49.		
		Totals	613.6	445.2	147.1	68.4

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New York Central Installs First Complete Train Dispatching System. By B. J. Schwendt. *Railway Age,* August 20, 1927.

Article, fully illustrated, describing central control system.

Pere Marquette Installs Centralized Control Signal System. *Railway Age,* October 6, 1928.

Article, fully illustrated, describing central control system.

Train Operation by Signal Indication. Report by A.R.A. Signal Section Committee I—Economics of Railway Signaling. Signal Section Proceedings, April, 1925.

This report includes the following:

Papers describing train operation by signal indication installations on:

Boston & Maine, by W. Y. Scott.
Central New England, by W. F. Follett.
Central of Georgia, by E. B. DeMeritt.
Chesapeake & Ohio, by B. T. Anderson.
Chicago, Burlington & Quincy, by J. B. Latimer.
Delaware, Lackawanna & Western, by J. E. Saunders.
Erie, by M. A. Baird.
Gulf, Colorado & Santa Fe, by E. Hanson.
Illinois Central, by H. G. Morgan.
Nashville, Chattanooga & St. Louis, by G. S. Pflasterer.
New York Central, by H. S. Balliet.
New York, New Haven & Hartford, by C. H. Morrison.
Ohio Central, by B. J. Schwendt.
Pennsylvania, by W. M. Post.
Pennsylvania, by A. H. Rudd.

Other papers:

Train Orders and Signal Indications, by Azel Ames.
Train Operation by Signal Indication, by G. M. Basford.
Dispatching Trains by Signal Indication, by Stanton Ennes.
Eliminating the Train Order, by H. W. Griffin.
Signaling at the Age of Maturity, by S. N. Wight.

Train Operation by Signal Indication. By H. M. Sperry. *Railway Age,* June 4, June 11, 1920.

A study of the different methods of train operation including single track operation without written train orders.

Appendix D

(5) PREPARE AND SUBMIT AS INFORMATION THE CURRENT ACTIVITIES OF THE SIGNAL SECTION, A.R.A., SUPPLEMENTED WITH LIST AND REFERENCE BY NUMBER OF ADOPTED SPECIFICATIONS, DESIGNS AND PRINCIPLES OF SIGNALING PRACTICE

W. M. Vandersluis, Chairman, Sub-Committee; H. G. Morgan, Vice-Chairman, Sub-Committee; F. W. Pfleging.

There is given below a synopsis of the principal current activities of the Signal Section, American Railway Association:

Study of the effect of installing automatic signals.

A report on the economic value of remote power switch machines.

Revision of specifications covering mechanical interlocking, electro-mechanical interlocking, draw-bridge circuit controllers, time locks, electric locks, installation of wires and cables, electric motor switch operating and locking mechanism and time releases.

Use of steel taped cable in lieu of wood trunking.

Method of keeping interlocked switches free from snow and ice.

Revision of specifications covering direct current motor semaphore signals, direct current relays, concrete trunking and annunciator bells.

Additional definitions of technical terms used in signaling have been prepared.

Three additional chapters to the book on "Signaling" have been prepared for discussion. These are Chapter III, Principles of Railway Signaling, Chapter XII, Semaphore Signals, and Chapter XIII, Light Signals.

The work on standard drawings, both new and revision of present standards, has progressed.

The table of revised signal and interlocking units with their values has been completed and a table covering certain auxiliary units used in signaling has been prepared for discussion.

Reports have been made covering co-operative work on standards for storage batteries and dry cells with a revision of the cylindrical dry cell specifications. Work has also been done through co-operative action on reduction in number of stock sizes of metal and fibre flash light cases.

Revision has been made of specification for rubber compound insulated signal wire for 660 volts or less, and a new specification for parkway cable has been submitted.

The development on highway crossing protection and the use of traffic signals at grade crossings has been presented.

There follows a list of specifications by Manual part number, specification number, description and approval date of those now in effect:

Part No.	*Spec. No.*	*Description of Specification*	*Approval Date*
2	7319	Alternator	May, 1920
3	11221	Portable A.C. Ammeters	Nov., 1921
4	8620	Alternating Current Automatic Block Signal System	Mar., 1921
5	6324	Direct Current Automatic Block Signals—Low Voltage	July, 1924
6	8720	Type "A" Caustic Soda Primary Cells and Renewals	Mar., 1921
8	3328	Gravity Battery Coppers	July, 1928
9	11328	Battery Jar (Primary)	July, 1928
10	3428	Gravity Battery Zincs	July, 1928

Part No.	*Spec. No.*	*Description of Specification*	*Approval Date*
11	11622	Cement Concrete Battery Box	Nov., 1922
12	11728	Battery Jar (Storage)	July, 1928
13	4328	Electrolyte (Lead Type Storage Battery)	July, 1928
15	4915	Nickel, Iron, Alkaline Storage Battery	1915
17	8820	Lead Type Portable Storage Battery for Signaling	Mar., 1921
18	5328	Storage Battery (Composite Type Stationary)	July, 1928
19	5828	Storage Battery (Pure Lead Type Stationary)	July, 1928
20	3513	Annunciator Bells	1913
21	4427	Direct Current Vibrating Highway Crossing Bell	July, 1927
22	13524	Bonding for Track Circuits	July, 1924
24	5416	Aerial Aluminum Cable Steel Reinforced	1916
25	8920	Aerial Braided Cable for 660 Volts or Less	Mar., 1921
26	9020	Rubber Insulated Armored Submarine Cable for 660 Volts or Less	Mar., 1921
27	9220	Armoured Submarine Cable for 2200 Volts	Mar., 1921
28	9120	Lead Covered Cable for 660 Volts or Less	Mar., 1921
29	9320	Lead Covered Cable for 2200 Volts	Mar., 1921
30	9420	Underground Braided Cable for 660 Volts or Less	Mar., 1921
31	12623	Cylindrical Dry Cells	Dec., 1923
32	2312	Copper or Tin Plated Channel Pin	1912
36	1111	Portland Cement Concrete	1911
37	6418	Impregnated Fiber Conduit for the Protection of Insulated Wires and Cables	1918
38	5516	Installation of Fiber and Metal Conduit Systems	1916
39	3613	Steel Pipe Conduit	1913
40	3713	Wrought Iron Pipe Conduit	1913
41	2412	Vitrified Clay Conduit	1912
42	4514	Installation of a Vitrified Clay Conduit System	1914
48	13023	Drawbridge Circuit Controller First and Second Range Voltage	Dec. 1923
49	9520	Universal Switch Circuit Controllers	Mar., 1921
50	5028	Copper Sulphate	July, 1928
51	2512	Wood Crossarms	1912
52	2612	Crossarm Braces and Heel and Toe Bolts	1912
53	2712	Steel Crossarm Pins	1912
54	2812	Crossarm Through Bolts and Double Arm Bolts	1912
57	1211	Gasoline Engine with Fuel and Water Tanks	1911
58	1323	Hard Fiber	Dec., 1923
61	3813	Fuses	1913
62	9620	Renewable Cartridge Fuses	Mar., 1921
63	2912	Galvanizing for Iron or Steel	1912
64	13324	Motor Gasoline	July, 1924
65	1411	Electric Generator	1911
66	5927	Hand Lantern Globes	July, 1927
67	7419	Impedance Bond	May, 1920
69	13123	Direct Current Indicator	Dec., 1923
70	9720	Alternating Current Indicator or Repeater	Mar., 1921
75	6528	Installation of Electric Interlocking	July, 1928
76	6628	Installation of Electro-Mechanical and Mechanical Interlocking	July, 1928
77	12526	Electro-Mechanical Interlocking Machine, S. & F. Miniature Locking	July, 1926
78	13226	Electro-Mechanical Interlocking Machine, Unit Electric Levers, S. & F. Locking	July, 1926
79	6725	Electro-Pneumatic Interlocking	July, 1925
80	14428	Porcelain Insulation	July, 1928

Part No.	*Spec. No.*	*Description of Specification*	*Approval Date*
82	7527	Mechanical Interlocking Machine, S. & F. Locking	July, 1927
83	11427	Mechanical Interlocking Machine Style "A" Locking	July, 1927
84	11922	Electric Wiring for Interlocking Plants. First and Second Range Voltage	Nov., 1922
85	7619	Power Interlocking Machine	May, 1920
88	1611	Gray Iron Castings	1911
89	1711	Malleable Iron Castings	1911
90	1811	Wrought Iron Bars	1911
91	5115	Incandescent Electric Lamps	1915
92	6017	Made Ground Apparatus for Lightning Arresters	1917
95	5215	Vacuum Gap Lightning Arresters	1915
96	9920	Electric Lock for Interlocking Machines. First and Second Range Voltage	Mar., 1921
97	12724	Time Locks	July, 1924
98	9820	Universal Electric Lock for Hand Operated Switches. First and Second Range Voltage	Mar., 1921
103	10020	Direct Current Motor Operated, First Range Voltage High Signal Mechanism	Mar., 1921
104	10120	Universal Electric Motor Switch Operating and Locking Mechanism. First and Second Range Voltage	Mar., 1921
105	1911	Illuminating Oil	1911
106	10220	Zero Fahrenheit Lubricating Oil	Mar., 1914
107	10320	45 Degrees Below Zero Fahrenheit Lubricating Oil	Mar., 1921
108	4614	Transformer Oil	1914
110	12022	Paint and Painting	Nov., 1922
111	7719	Petroleum for Use in Impedance Bonds	May, 1920
112	6117	Petroleum Asphaltum to Protect Wires in Trunking	1917
113	12127	Compensation of Pipe Line for the Operation of Mechanical Units	July, 1927
114	12227	One-Inch Welded Steel Pipe	July, 1927
116	12324	One-Inch Wrought Iron Signal Pipe	July, 1924
117	3012	Eastern White Cedar Poles	1912
119	3913	Push Buttons Used for the Operation of Bells, Annunciators and Similar Devices	1913
120	4013	Floor Pushes	1913
121	10420	Air-Cooled Reactor for Line and Track Circuits	Mar., 1921
122	7819	Alternating Current Relay	May, 1920
123	10520	Tractive Armature Direct Current Neautral Relays	Mar., 1921
129	12824	Time Releases	July, 1924
135	10628	Resistor	July, 1928
136	6918	Signal Roundels, Lenses and Glass Slides	1918
144	7919	Alternating Current Motor Semaphore Signal	May, 1920
145	2011	Direct Current Motor Semaphore Signal	1911
146	8019	Electric Color Light Signal	May, 1920
147	8119	Electric Position Light Signal	May, 1920
152	2111	Machinery Steel	1911
153	10720	Switchboard (A.C. Signal System)	Mar., 1921
155	6217	Switchboard Material	1917
157	8226	Friction tape for Railroad Use	July, 1926
158	5616	Rubber Insulating Tape	1916

Part No.	Spec. No.	Description of Specification	Approval Date
164	8319	Single Phase, Air Cooled Track Transformer	May, 1920
165	8419	Single Phase, Line Transformer, Oil Immersed Self-Cooled	May, 1920
166	12422	Concrete Trunking, Capping and Supports	Nov., 1922
167	5728	Trunking and Capping	July, 1928
168	8519	Portable Direct Current Volt Ammeters	May, 1920
169	11528	Voltmeter (Portable A.C.)	July, 1928
175	10820	Copper Bond Wire	Mar., 1921
176	7018	Copper Clad Steel Bonding Wires	1918
177	2211	Galvanized E. B. B. Bonding Wires	1911
179	11020	Wire Joints	Mar., 1921
180	7118	Thirty Per Cent Conductivity, Hard Drawn Copper Clad Steel Line Wire	1918
181	3212	Double Braided Weatherproof Galvanized B.B. Line Wire	1912
182	7218	Double Braided Weatherproof Hard Drawn Copper Line Wire	1918
183	4113	Enameled Copper Magnet Wire	1913
184	4714	Galvanized Messenger Wire	1914
186	11120	Mineral Matter, Rubber Compound Insulated Signal Wire for 660 Volts or Less	Mar., 1921
191	....	Electric Light, Power Supply and Trolley Lines Crossing Railways	July, 1928
192	4213	Crossings of Wires or Cables of Telegraph, Telephone, Signal and Other Circuits of Similar Character Over Steam Railroad Rights-of-Way, Tracks or Lines of Wires of the Same Classes	**1913**
193	13425	Electro-Mechanical Interlocking Machine Vertical Locking	July, 1925
195	7002	Switch Circuit Controller Shunting Circuit Resistance Test	July, 1925
196	7003	Train Shunt Resistance Test	July, 1925
197	13826	Application of Electric Locks and Circuit Controllers to Mechanical Interlocking Machines, Using Saxby & Farmer Locking	July, 1926
202	14026	Preservative Treatment of Capping and Grooved Trunking	July, 1926
204	13726	Oil Lighted Lamps	July, 1926
206	7004	Fouling Protection	July, 1927
207	14328	Transformers (for Singal Lighting and or for the Operation of Rectifiers Charging Storage Batteries)	July, 1928
208	14128	Installation of Automatic Interlocking	July, 1928

Below is given a list of rules, reports and principles of recommended practice, reference being made to Manual part number, description and approval date.

Part No.	Description of Rules, Reports and Principles	Approval Date
7	Instructions for Installation and Handling of Caustic Soda Batteries	July, 1927
14	Instructions for Installation, Maintenance and Operation of Lead Acid Type Storage Batteries	July, 1924
16	Instructions for Installation, Maintenance and Operation of Nickel, Iron, Alkaline Storage Batteries	July, 1925

Part No.	*Description of Rules, Reports and Principles*	*Approval Date*
23	Requirements for the Protection of Traffic at Movable Bridges	1916
33	Circuit Nomenclature and Written Circuits	1914
34	Requisites for Direct Current Automatic Block Signaling Circuits	Nov., 1922
35	Clearance Diagram	1911
43	Form of Contract for Block Signal and Interlocking Work	Dec., 1923
44	Form of Contractor's Proposal for Block Signal and Interlocking Work	Nov., 1921
45	Form of Bond to Accompany Contract for Block Signal and Interlocking Work	Nov., 1921
46	Form of Invitation to Bidders on Block Signal and Interlocking Work	July, 1924
47	Conclusions as to Methods of Control to Cause Signals to Indicate Stop in Emergencies	Mar., 1921
55	Definition of Technical Terms Used in Signaling	July, 1928
56	Non-Use of Derails	July, 1927
59	Non-Use of Forms for Recording Signal Performance	1914
60	Standard Forms for Reporting Material Used and Labor Performed in Construction	Nov., 1922
68	Principles of Signal Indications	1912
71	Take Siding Indicator	Nov., 1921
72	Switch Indicators	1916
73	Instructions for Maintaining and Handling Dry Cells	July, 1927
74	Instructions for Maintenance of Gravity Cells	1915
81	Requisites for Minimizing the Effect of Lightning on Direct Current Track Circuits	July, 1927
86	Interlocking Units and Values, Distribution Form 22	Dec., 1923
87	Table of Interlocking Units and Values	July, 1924
93	Requisites for Lightning Arresters for Signaling	1915
94	Requisites for Choke Coils for Signaling	1915
99	Requisites for Mechanically Interlocking the Levers of Interlocking Machines	July, 1927
100	Questions and Answers for Signal Maintainers	Mar., 1921
101	Examination Papers on Signal Maintenance	Nov., 1921
102	Rules for Signal Maintenance	Nov., 1921
109	Overlaps in Connection with Automatic Signal Systems	1918
115	Pipe Thread	Nov., 1922
118	Information for Calculating Power Supply and Distribution	Nov., 1921
124	Instructions for Inspecting and Testing Alternating Current Relays and Indicators	Dec., 1923
125	Direct Current Relays. Comparisons on the Use of 2-.ohm and 4-.ohm Relays	1918
126	Instructions for Inspecting and Testing Direct Current Relays	July, 1927
127	Requisites for Minimizing the Effect of Foreign Current on Direct Current Track Circuits	July, 1927
128	Rules for the Setting of Time Releases Applied to Signal or Switch Apparatus	Mar., 1921
130	Measurement of Insulation Resistance	July, 1924
131	Direct Current Track Circuit Rail and Ballast Resistance Report	Nov., 1922
132	Formula for Computing Limiting Resistances in Series with Track Battery	Nov., 1922
133	Tables of Minimum Limiting Resistance Allowable in Series with Track Battery	Nov., 1922

Part No.	Description of Rules, Reports and Principles	Approval Date
134	Curves for Determining Minimum Limiting Resistance Allowable in Series with Track Battery for Various Train Shunt Resistances and Various Battery Voltages	Nov., 1922
137	Rules Governing Maintenance of Block Signals	1914
138	Rules Governing Maintenance at Interlocking Plants	1918
139	Rules Governing Signal Foremen	1911
140	Rules Governing Signal Supervisors	1914
141	Table of Average Service Life in Years of the Important Units of the Different Types of Signal Installations	Nov., 1922
142	Construction Program for Signaling	Nov., 1922
143	Signaling Practice	1912
148	Requisites for Highway Crossing Signals	July, 1928
149	Requisites for Light Signals for Day and Night Indications	Nov., 1921
150	Method of Testing First Range D.C. Upper Quadrant Motor Signal in Service	Nov., 1922
151	Signs or Markers for Conveying Instructions to Enginemen and Recommendations	1918
154	Instructions for Installation and Operation of Switchboard	July, 1928
156	Requisite Sheet for Switchboard Material	1917
159	Electric Wire and Cable Terminoloy	1916
160	Instructions for Making Shop Torque Tests at the Semaphore Shaft of Power Operated Signals	Nov., 1921
161	A.C. Track Circuit Characteristics	July, 1926
162	Instructions for the Adjustment, Care and Operation of A.C. Track Circuits	Dec., 1923
163	Automatic Train Control	1914
170	Voltage Ranges for Signal Work	1912
171	Requisites for Impregnating Compound Treatment of Non-oilproof Electrical Windings	Nov., 1922
172	Requisites for Impregnating Compound Treatment of Partially Oilproof Electrical Windings	Nov., 1922
173	Requisites for Impregnating Compound Treatment of Oilproof Electrical Windings	Nov., 1922
174	Requisites for Varnish Treatment of Electrical Windings	Nov., 1922
178	Wire Inspection Report	1919
185	Recommended Sags for Messenger Wire	1914
187	Insulation Resistance in Megohms per Mile at 60 Degrees Fahrenheit	1919
188	Requisites for Minimizing the Sweating of Relays	July, 1927
189	Tables of Wires Required for Stranded and Flexible Conductors	1919
190	Instructions for Handling Insulated Wires and Cables	July, 1924
194	Signal Layout for Remote Switches	July, 1925
198	Factors Which Govern in Determining the Type of Interlockings Which Should be Installed	July, 1926
199	Testing Electric Locking	July, 1926
200	Instructions for Inspecting and Testing Mechanical Locking of an Interlocking Machine	July, 1926
201	Resistances of D.C. Relays	July, 1926
203	Example of Use of Unit Value Basis	July, 1926
205	Requisites for Minimizing the Sweating of Semaphore Signal Mechanisms	July, 1927

The number of current standard drawings is so large that reference is made to the index portion of the standard drawing section of the Signal Section Manual, pages 1 to 32, inclusive.

6. That the report in Appendix F be received as a progress report and the subject be reassigned for further study.

7. That subjects 1, 2, 4, 5 and 6 be reassigned and that two new subjects be assigned, namely:

(a) "Prepare Recommended Clearance Diagrams for both Main and Subsidiary Tracks adjacent to or entering Building Structures."

(b) "Waterproofing and Dampproofing as applied to Building Construction."

Respectfully submitted,

THE COMMITTEE ON BUILDINGS,

FRANK R. JUDD, *Chairman.*

Appendix A

(1) REVISION OF THE MANUAL

A. L. Sparks, Chairman, Sub-Committee; G. A. Belden, A. C. Copland, E. W. Everett, E. A. Harrison, E. A. Johnson, O. G. Wilbur.

All the subject-matter included in the 1921 edition of the Manual has been checked and reviewed during the past few years and the suggested revisions have been printed in the Proceedings and adopted for publication, as follows:

1. DEFINITIONS.—No change from the 1921 Manual.

2. ASHPITS.—At the 1923 convention it was voted to withdraw the text included in the Buildings Section and submit therefor the text published in Bulletin 257, pages 87-89.

3. ENGINE HOUSE DESIGN.—It was also voted to withdraw this text included in the Buildings section and submit therefor the text as submitted by Committee on Shops and Locomotive Terminals, as recommended in Bulletin 250, pages 79-82.

4. FREIGHT HOUSES.—Recommendations have been adopted for the revision of the text on freight houses as indicated in Bulletin 287, pages 41-46.

5. OIL HOUSES.—Recommendations for revision of the text on oil houses are to be found in Bulletin 287, pages 46 and 47, with further revisions in Bulletin 294, pages 660.

6. REST HOUSES.—Recommendations for the revision of text on rest houses are to be found in Bulletin 287, pages 47-49, with further revisions in Bulletin 294, page 661.

7. PASSENGER STATIONS.—Recommendations for the revision of text on passenger stations are found in Bulletin 287, pages 49-55, with further revision in Bulletin 294, pages 661 and 662.

8. SECTION TOOL HOUSES.—Recommendations for the revision of text on section tool houses are to be found in Bulletin 287, page 55.

9. Roofing.—Recommendations for roofing have been published in Bulletin 237, pages 56-60.

10. Ice Houses and Icing Stations.—Recommendations for changes in the text on this subject have been published in Bulletin 287, pages 60 and 61.

11. Floors for Railway Buildings.—Recommendations for floors for railway buildings are published in Bulletin 287, pages 61-63.

12. Paint for Railway Buildings.—Recommendations for paint for railway buildings are published in Bulletin 287, pages 63-67.

13. Location and Design of Signs for Passenger Stations.—Recommended text for this subject is published in Bulletin 287, pages 67-68.

14. Permissible Grades for Ramps for Railway Buildings.—This subject is being handled by the Yards and Terminals Committee.

15. Specifications for Buildings for Railway Purposes.

Sections 1 to 11, inclusive, have been accepted for publication including 10-A, 10-B, 10-C, 10-D.

Section 12 has been accepted as published in Bulletin 294 with revisions as voted at the 1927 convention and published in Volume 28 of Proceedings, pages 1419 to 1423.

Section 13 to 20, inclusive, have been accepted for publication in the Manual.

Revision of Manual

The Buildings Committee have no further changes to recommend for the first fourteen subjects, but for subject 15, Specifications for Buildings for Railway Purposes, the following changes are recommended:

Section 5. Brickwork.—It is recommended that the last sentence in Article 3 be revised to read: "Porous or salmon brick shall be thoroughly wetted either by immersion or sprinkling before being laid, except in freezing weather."

It is further recommended that this sentence be repeated at the end of Article 4. It is recommended also that Article 7 be changed to read: "Cement: The cement shall meet the requirements of the American Railway Engineering Association's 'Specifications for Portland Cement.' Cement that has hardened or partially set shall not be used."

Section 6. Stone Masonry and Cut Stone.—It is recommended that beginning with the next to last sentence in Article 7 the text be changed to read: "The cement shall meet the requirements of the American Railway Engineering Association's 'Specifications for Portland Cement.' Cement that has hardened or partially set shall not be used."

"Sand shall be clean, sharp, coarse and of grains varying in size. It shall be free from sticks or other foreign matter, but it may contain clay or loam not to exceed 2 per cent. Where so required for pointing face work, sand shall be clean, sharp, white sand of the very best quality."

"Lime used shall be of good quality, in large lumps, free from cinders, or clinkers, must contain less than ten per cent impurities and must slake readily in water, making a very soft paste, free from core. Before being used all lime shall be thoroughly slaked with water. No air slaked lime shall be used. The use of hydrated lime of approved brand will be permitted at the discretion of the Engineer."

Section 12. Structural Steel and Iron.—It is desired to change the number to Section 12-A in view of adding another section 12-B covering Ornamental and Miscellaneous Metal Work.

Section 13. Carpentry and Mill Work.—It is suggested that a sentence be added to Article 20 reading: "All glass and glazing shall conform to Section 16: Painting and Glazing, Articles 24 and 26." It is also suggested that the third sentence of Article 14 be changed to read: "Treads shall have molded nosings, be ploughed into risers and risers into the underside of the treads, and both housed into the wall stringer, tightly wedged and glued."

Section 15. Marble and Tile Work.—It is suggested that an additional paragraph be added to Article 9—Terrazzo, to read as follows: "Contractor shall submit finished samples not less than six inches square showing the color and finish for the Engineer's approval before work is started."

Section 16. Painting and Glazing.—It is suggested that Article 13 be changed to read as follows: "Where enameled finishes are called for on wood or plastered surfaces, these surfaces shall be given three coats of flat white, each of which shall be lightly sandpapered before the succeeding coat is applied, and shall then be given two coats of approved enamel applied in accordance with the manufacturer's instructions."

Appendix B

(2) SPECIFICATIONS FOR CONCRETE USED IN RAILWAY BUILDINGS

W. T. Dorrance, Chairman, Sub-Committee; H. Filippi, A. C. Irwin, F. R. Judd, A. M. Knowles, J. W. Orrock.

In view of the recent developments in the practice of construction in concrete this Committee has prepared an entirely new draft of its specifications. This draft has been discussed by the Committee on Buildings and certain corrections suggested but the final draft has not been completed in time for proper collaboration with Committee VIII—Masonry. Therefore the specification is not submitted to the Association at this time, and it is asked that the subject be reassigned for further study.

Appendix C

(3) COLLABORATE WITH COMMITTEE XII—RULES AND ORGANIZATION IN THE STUDY OF RULES AND REGULATIONS FOR EMPLOYEES OF THE BUILDINGS DEPARTMENT

O. G. Wilbur, Chairman, Sub-Committee; H. G. Dalton, F. M. Davison, E. A. Johnson, E. K. Mentzer, G. A. Rodman, J. C. Williams, A. H. Williamson.

This Sub-Committee prepared a set of rules for employees of the Buildings Department and submitted them in report form at the meeting of Committee VI in Toronto last August. This report was discussed in detail and corrected at the Toronto meeting, after which it was submitted to B. R. Kulp, Chairman of the Sub-Committee of Committee XII—Rules and Organization.

It is our understanding that the Committee on Rules and Organization will include this matter in their final report and that it will be submitted to the Association.

Therefore it is asked that this subject be discontinued from the work of the Committee on Buildings.

Appendix D

(4) DESIGN AND CONSTRUCTION OF WATER STATION BUILDINGS

Eli Christiansen, Chairman, Sub-Committee; F. M. Davison, H. Filippi, W. H. Hobbs, R. E. Mohr, O. M. Rognan.

A tentative final report with recommendations and conclusions has been drawn up but inasmuch as this report was not available for final action on the part of Committee VI, it is asked that this subject be reassigned for further study and final action.

Appendix E

(5) SPECIFICATIONS FOR BUILDINGS FOR RAILWAY PURPOSES

J. W. Orrock, Chairman, Sub-Committee; W. T. Dorrance, F. R. Judd, R. E. Mohr, A. L. Sparks, A. T. Upson.

The specifications published in Appendix H, pages 939 to 965 of Bulletin 304, Vol. 29, 1928, and approved for publication in the Proceedings, are now submitted for publication in the Manual. These specifications are Sections 22, Concrete Paving; 23-A, Wood Block Paving; 23-B, Wood Block Flooring; No. 25-A, Asphalt Block Paving; 25-B, Asphalt Block Flooring; 26-A, Macadam Paving, and 26-B, Asphalt Macadam Paving.

At this time Sections 12-B, Ornamental and Miscellaneous Metal Work; 21, Brick Paving and Flooring, and 27, Sprinkler Systems, are submitted as information for publication in the Proceedings and for criticism of the Association with the view of submitting them at a later date for publication in the Manual. The sections submitted at this time follow:

SPECIFICATIONS FOR RAILWAY BUILDINGS

SECTION 12-B

Ornamental and Miscellaneous Metal Work

1. **General**

The Contractor shall furnish all labor, material, tools and equipment necessary to entirely complete the ornamental and miscellaneous steel, iron, bronze, brass or other similar metal work as herein specified and as called for on the drawings.

2. **Drawings**

The general design of all ornamental and miscellaneous metal work will be shown on drawings furnished by the Company, and details which are not shown on these drawings shall be detailed on the shop drawings furnished by the Contractor. Full size drawings, conforming to design drawings, may be furnished by the Company at its option after contract is let.

3. **Unit Stresses**

Ornamental and miscellaneous metal work shall be so proportioned that the unit stresses will not exceed those herein set forth.

	Working Stress in Pounds per sq. in.			
	Tension	*Compression*	*Shear*	*Bearing*
Aluminum, cast	3,000	3,000	3,000	3,000
Aluminum, rolled	6,000	6,000		
Aluminum, drawn or extruded	12,000	12,000		
Aluminum, drawn or extruded and annealed	7,000	7,000		
Aluminum alloy, 2 per cent to 7 per cent M, cu, iron, etc	9,000	9,000	6,000	10,000
Aluminum bronze, 10 per cent aluminum	18,000	18,000	12,000	20,000
Aluminum bronze, 5 per cent to 7½ per cent aluminum	12,000	12,000	8,000	12,000
Brass, 17 per cent to 30 per cent zinc cast	4,000			
Brass, 40 per cent to 50 per cent zinc cast	8,000			
Brass, 17 per cent to 30 per cent zinc rolled, drawn or extruded	8,000			
Brass, 40 per cent to 50 per cent zinc rolled, drawn or extruded	16,000			
Bronze, 8 per cent to 24 per cent tin cast	8,000			
Bronze, 30 per cent tin cast	11,000			
Bronze, 8 per cent to 24 per cent tin, rolled, drawn or extruded	8,000			
Bronze, 30 per cent tin, rolled, drawn or extruded	11,000			
Bronze, Tobin cast	12,000	12,000	10,000	16,000
Bronze, Tobin rolled, drawn or extruded	18,000	18,000	12,000	20,000
Cast iron	3,000	12,000	3,000	12,000
Cast iron malleable	6,000	12,000	6,000	12,000
Cast steel	18,000	18,000	12,000	20,000
Copper, cast	3,000	10,000	3,000	10,000
Copper, rolled, drawn or extruded	6,000	10,000	6,000	10,000
Steel, rolled	18,000	18,000	12,000	20,000
Steel, drawn or extruded	30,000	30,000	20,000	30,000
Wrought iron, rolled	14,000	14,000		
Wrought iron, drawn or extruded	18,000	18,000		

Columns of any of the above metals shall be proportioned by the formula $18{,}000 - 60\frac{l}{r}$ in the ratio that its working compression stress bears to 18,000.

Column lengths shall be limited to two hundred (200) times the least radius of gyration when they bear any load.

4. Steel

Rolled steel shall be made by the open-hearth process and otherwise shall comply with the "Standard Specifications for Structural Steel for Buildings" of the American Society for Testing Materials, Serial Designation A-9.

Cast steel shall be in accordance with the "Standard Specifications for Steel Castings," Class "B" of the American Society for Testing Materials, Serial Designation A-27.

Where copper-bearing steel is specified, it shall contain not less than two-tenths of one per cent (2/10 per cent) copper.

5. Wrought Iron

Wrought iron shall comply with the "Standard Specifications for Refined Wrought Iron Bars" of the American Society for Testing Materials, Serial Designation A-41.

6. Cast Iron

Cast iron shall comply with the "Standard Specifications for Gray Iron Castings" of the American Society for Testing Materials, Serial Designation A-48.

7. Miscellaneous Metals

Non-ferrous metals and alloys of ferrous and non-ferrous nature shall comply with the current specifications of the American Society for Testing Materials.

Bronze castings shall be made from a standard bronze metal adapted to fine castings. Sheet bronze shall be rolled bronze plate and shall match cast bronze in color.

8. Castings

Ornamental castings shall be made in stove plate molding sand. Cast metal shall be uniform in thickness throughout, free from sand, holes or other defects. Ornamental castings shall not exceed three-eighths inch (3/8") in thickness unless shown on drawings or otherwise permitted. Ornamental details shall be strictly adhered to and profiles made in strict accordance with full size drawings. Surface lines and straight line moldings shall be hand filed, ground and soft wheeled. Ornamental detail shall be modeled in clay and then cast directly from the plaster reproduction of the clay model. No ornamental detail shall be cast from wood patterns or molds.

The exposed surfaces of ornamental castings shall be perfectly clean and sharp with the ornamental detail brought out clear and strong, well modeled in good relief and undercut when necessary and with all lines, arrises, profiles and ornament true and in accordance with details and approved models. Pierced work shall have openings and outlines free from irregularities. Castings shall be neatly filed and chased to remove any superficial imperfections and shall be altered if necessary until they are satisfactory to the Engineer in all respects.

Bronze castings shall be made from electro-plated metal patterns in molds with special facings and shall be hand filed, chased and carefully finished.

9. Pipe Railing

Where shown on drawings, pipe railing shall be made of seamless, commercial wrought iron pipe. The railing shall be fitted with standard malleable iron railing fittings. Where set on masonry, the flanges shall be securely anchored with one-half inch (1/2") by four inch (4") expansion bolts. Where attached to steel or iron work they shall be securely bolted and lock nuts used. Where attached to wood they shall be securely fastened with appropriate wood or lag screws or bolts. Railing shall be designed to withstand a horizontal pressure of not less than 50 lb. per linear foot.

10. Fabric Fences

Where shown on drawings, fabric fences shall be made of copper bearing steel and hot dipped galvanized. Fabric shall be galvanized after weaving. Posts shall be set not less than three feet (3') deep into bell shaped concrete footings shaped at the top to shed water and affording a minimum covering of two inches (2") over the steel. Posts shall be thoroughly stayed, braced and anchored in two directions at ends of each run and at every change in direction. Fences shall be designed to withstand a horizontal pressure of not less than 25 pounds per square foot.

11. Wrought Iron Fences

Where shown on drawings, fences shall be made of wrought iron. Wrought iron fences may be either hot or cold riveted or welded. Posts shall be set not less than three feet (3') deep into bell shaped concrete footings shaped at the top to shed water and affording a minimum covering of two inches (2") over the metal. Posts shall be thoroughly braced or stayed transversely with the line of the fence. Fences shall be designed to withstand a horizontal pressure of not less than 25 pounds per square foot.

12. Stairs, Balconies and Ladders

Stairs and balconies shall be designed for a live load of 100 pounds per square foot. Ladders shall be designed for a live load of 300 pounds upon each rung. Stairs shall be equipped with an approved anti-slip tread. Spiral stairs will not be permitted unless specifically authorized by the Engineer.

13. Fire Escapes

Fire escapes shall comply with local laws and ordinances but shall be designed for a live load of not less than 100 lb. per square foot. Fire escapes shall also comply with the requirements of the National Board of Fire Underwriters. Railing shall be able to withstand a horizontal pressure of 50 lb. per linear foot.

14. Flagpoles

Flagpoles shall be made of tubular sections of copper bearing steel, genuine wrought iron, or other corrosion resisting metal. Sections shall be in graduating sizes, each length being shrunk into the next larger size and welded to an absolutely watertight joint.

For important work and where directed by the Engineer, poles shall be continuous taper welded of conical section without any visible joints throughout. Small outrigger flagpoles shall always be continuous taper welded.

Flagpoles shall be absolutely watertight at both top and bottom and throughout their length to prevent any internal corrosion. Poles shall be equipped with ball or other suitable capping, a ball bearing, non-fouling swival top or truck and cleats. The truck shall be equipped with two sheaves of suitable size. All attachments shall be of non-corrosive metal.

Flagpoles shall be designed to withstand a horizontal wind pressure of fifty (50) lb. per square foot of projected area of the pole in addition to the weight of the pole. Flagpoles shall be anchored to withstand twice the overturning moment from the above specified wind pressure.

Poles in the ground shall be set in bell shaped or other massive concrete foundations.

Unless otherwise specified flagpoles on roofs shall be of the tilting type so counterweighted that they can be operated by one man. All connections to roof shall be made watertight.

When poles pass through or are fastened to roof, they shall be provided with suitable flashing collars, caulked, and made watertight at roofs.

15. Column Guards, Door Guards and Jambs

Column and door guards and jambs shall be cast iron unless otherwise called for. The metal must be of sufficient thickness to properly protect columns, walls, etc., and form watertight connections to them.

16. Window Guards, Elevator Enclosures and Grille Partitions

Window guards shall be so fastened to the window frames or building that they cannot be removed from the outside. Wire for window guards, elevator enclosures or grille partitions shall be not less than No. 10 American Steel & Wire Company gage nor shall the mesh be larger than one and one-half inches (1½"). Mesh may be either diamond or square and when not interwoven it shall be fastened at each intersection and shall be hot dipped galvanized.

Elevator enclosures and grille partitions may be either woven or fabricated from flat metal. Flat metal shall be not less than No. 16 United States gage, nor less than three-eighths inch (⅜") in width. Fabricated construction shall have no openings greater than one and one-half inches (1½") and all strands shall be fastened securely at each intersection.

Window guards, elevator enclosures and grille partitions shall be designed to withstand a horizontal pressure of not less than 25 pounds per square foot and all fastenings and details shall develop the main material.

17. Marquise

Marquise shall be designed to withstand a load of twenty-five (25) lb. per square foot in addition to the dead load and also an uplifting wind load of twenty (20) lb. per square foot, unless local laws or ordinances require otherwise.

18. Metal Frames for Doors and Windows

Metal frames for doors and windows shall match the metal doors and sash to be fitted into them and shall be of the same type and style. Frames shall be equipped with suitable anchors and bolts to fasten them to walls and structural parts of building and to make a watertight joint. Contractor shall furnish details of metal frames for approval.

19. Metal Doors and Fire Doors

Metal doors may be either swinging, rolling or sliding and of solid or hollow sections. Doors shall be so counterweighted and balanced that they may easily be operated by one man. No metal shall be less than No. 22 U.S. standard gage and if of steel shall be copper bearing.

Doors shall be complete with track, hangers, bumpers, counterweights, stops, stay rollers, door pulls, locks and chafe and binder strips.

Doors shall be stiff enough to resist bending and warping and when of hollow section shall be absolutely watertight to prevent internal corrosion.

Fire doors shall meet all the requirements specified above for metal doors and shall meet the requirements of the National Board of Fire Underwriters for particular use intended.

20. Metal Clad Doors and Fire Doors

Metal clad doors shall consist of cores of not less than 2-ply of sound, kiln dried, non-resinous wood, covered with not less than 20-lb. weight prime terne plate. The non-resinous wood may be either cedar, cypress, white pine, northern pine, redwood, eastern spruce, Sitka spruce, yellow poplar or Douglas fir, but only one kind of wood may be used in any one door. Terne plate shall be I.C. base weight (107 lb.) or heavier, of an alloy of not less than 20 per cent tin and the balance lead and the 20-lb. weight shall be in accordance with the Simplified Practice Recommendations of the U.S. Department of Commerce. All metal shall be made absolutely watertight to protect the wood cores. Each wood core shall be covered separately before doors are assembled. All metal clad doors shall be furnished complete as specified for metal doors.

Metal clad doors shall meet all of the requirements of the National Board of Fire Underwriters.

21. Metal Sash

Metal sash may be either solid or hollow section as indicated on drawings. No metal shall be less than No. 22 U.S. Standard gage and if steel, shall be copper-bearing. The type of sash and section shall be acceptable to the Engineer and the sash shall be of such sizes and units as are shown on drawings. Ventilators shall be located where shown on drawings. The manufacturer of the sash shall furnish and supervise the erection of the operators as well as the sash itself. Metal sash shall be equipped with necessary attachments for window cleaners' hooks both inside and outside of building.

22. Metal Covered Sash

Metal covered sash shall consist of cores of not less than 2-ply of sound, kiln dried, non-resinous wood, covered with not less than 20-lb. weight terne plate. The non-resinous wood may be either cedar, cypress, white pine, northern white pine, redwood, eastern spruce, Sitka spruce, yellow poplar or Douglas fir, but only one kind of wood may be used in any one sash. Terne plate shall be I.C. base weight (107 lb.) or heavier of an alloy of not less than 20 per cent tin and the balance lead and the 20-lb. weight shall be in accordance with the Simplified Practice Recommendations of the U.S. Department of Commerce. Metal shall be made absolutely watertight to protect the wood cores. Each wood core shall be covered separately before the sash are assembled. Metal covered sash shall be equipped with necessary attachments for window cleaners' hooks both inside and outside of building and shall comply with the requirements of the National Board of Fire Underwriters.

23. Metal Sash Operators

Sash operators shall be furnished and installed as called for on drawings.

All operators shall be so designed that both sides of all sash and both ends of all runs shall move at the same rate of speed and simultaneously to prevent twist and breakage of glass.

Operators for sidewall sash shall be of the rack and pinion type. Sidewall ventilators more than three (3) lights wide and which are to be mechanically operated shall be equipped with two operator arms.

Operators for metal monitor sash shall be of the tension type, no torsion type will be permitted.

Operators for runs of wood sash, not over thirty feet (30′0″) long, such as for roundhouse monitor sash, may be torsion type, worm gear, vertical rod and horizontal wheel.

Operators shall be fastened securely to the frame of the building and shall not be fastened to the brick walls of the building. Operators shall be braced back to panel points of the structural supports so that no bending is induced in any members. Brass bushings and washers shall be used at swivel points, worm gears shall be machine cut with thrust bearings.

Hand-operating devices for continuous operators shall be of the lever or gear type and not of the loose pull chain type.

When sash are motor operated, the Contractor shall furnish and install all motors, control boards, boxes and switches but not the wiring between the motors, control boards, boxes and switches. The Contractor shall furnish and install at each control box a diagram board showing the operation of the ventilators.

The Contractor shall furnish complete wiring diagrams for all work in connection with sash and sash operators.

Motors shall be of such size that the ventilators shall be opened or closed completely in not more than ten (10) seconds. The motors shall be of ample capacity to operate continuously for two (2) hours under full load without more than forty degrees (40°) Centigrade rise in temperature over surrounding atmosphere. Motors shall be designed for electrical current specified in each case by the Engineer and shall be placed where they are readily accessible for maintenance and repairs.

24. Sidewalk Doors, Covers and Gratings

Doors, covers and gratings over openings in sidewalks shall be designed to sustain the loads required by local ordinances but in no case less than one-hundred (100) lb. per square foot plus the dead weight of the structure. If constructed of steel, it shall be copper bearing steel.

25. Treads and Thresholds

All treads and thresholds and edges of landings shall have a type of a non-slip or safety surface. Treads and thresholds shall be equipped with suitable anchors and where exposed to moisture shall be composed of copper bearing steel or other corrosive resisting metal.

26. Gratings and Registers

Gratings around heating and ventilating apparatus and similar equipment shall be so designed that "free area" shall not be reduced and shall be readily removable for repairs to said apparatus. Dampers and registers shall be easily operated from outside without removing gratings or grilles and shall have operating device as nearly concealed as possible. The gratings or grilles shall be of such character that the apparatus behind them are concealed. Dampers in ceiling gratings shall be operated from the floor.

27. Ventilators and Smoke Jacks

Metal smoke jacks for enginehouses and ventilators for blacksmith shops and similar buildings shall be cast iron. Ventilators and smoke jacks shall be provided with dampers which can be operated from the floor.

28. Coal and Ash Doors and Hoppers

Coal and ash doors and hoppers and their frames shall be of heavy cast iron. When entering buildings, the doors shall be provided with suitable latches on the inside.

29. Joist Hangers, Column Caps and Bases

Joist hangers, column caps and column bases for wood columns may be either malleable cast iron, structural steel or wrought iron. Where subject to corrosion and if made of steel, the steel shall be copper-bearing.

30. Metal Ceilings

Metal ceilings shall meet the approval of the Engineer. Contractor shall submit detail drawings showing design, thickness of metal, supports and weights in detail. On steel buildings, concrete buildings or other fireproof structures metal supports shall be used.

31. Metal Partitions

Metal partitions for toilets, shower baths and in other locations where subjected to moisture shall be of corrosive resistant metal. Partitions shall be installed complete in place including all hardware, glazing and painting. Detail drawings shall be submitted to the Engineer for approval before ordering.

32. Anchors, Bolts, Ties, Wall Plates, Etc.

Anchors, bolts, ties, wall plates, etc., shall be steel and shall be copper-bearing.

33. Painting

Unless otherwise specified all steel and iron work shall receive one coat of approved paint in the shop and two field coats, as specified in Section 16 of these specifications covering Painting and Glazing. Office and other metal partitions shall have hard baked enamel finish of such colors as the Engineer directs.

34. General

All materials entering into the work and all methods used by the Contractor shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all of the work is completed.

The General Conditions as given in Section 1 of this specification shall be considered to apply with equal force to this section of the specification.

SECTION 21

BRICK PAVEMENTS AND FLOORS

1. General (Pavements and Floors)

The Contractor shall furnish all labor, material, tools and equipment, except as otherwise noted, necessary to entirely complete the work as specified and as shown or implied on the drawings.

2. Description (Pavements and Floors)

The work shall consist of a subgrade, a concrete foundation and a vitrified paving brick wearing surface laid over a cushion of either bituminous mastic, cement mortar or sand.

3. Grading, Subgrade and Foundation (Pavements)

The grading, subgrade and concrete foundation shall be constructed in accordance with the current specifications of the A.R.E.A. for Concrete Pavements, except that joints shall be omitted and the concrete finished to a smooth even surface exactly the depth below the finished pavement, corresponding to the combined depth of the paving brick and the bituminous mastic, cement mortar or sand cushion.

3. Subgrade and Foundation (Floors)

The subgrade, if one be needed, and the foundation shall be designed of sufficient strength to carry the loading to be encountered, and shall be constructed in accordance with the current specifications of the A.R.E.A. for Concrete for Railway Buildings as given in Section 4 of these specifications, except that the concrete shall be finished to a smooth, even surface, with no projection of any kind, parallel to the contour of and exactly the depth below the finished floor level, corresponding to the combined depth of the brick and the thickness of the bituminous mastic, cement mortar or sand cushion.

4. Curb and Gutters (Pavements)

The curb or the curb and gutter shall be built in the location and to the elevation, sizes and cross-section shown on drawings.

Cement and concrete materials and workmanship shall comply with the "Specifications for Concrete" as given in Section 4 of these specifications.

MATERIALS

5. Paving Brick (Pavements and Floors)

Paving brick shall comply with the requirements of the current Standard Specifications for Paving Brick of the American Society for Testing Materials, Serial Designation C-7.

Brick shall be vitrified and evenly burned, thoroughly annealed, tough and free from lime, air pockets, cracks or marked laminations. Kiln marks must not exceed three sixteenths (3/16") of an inch and one edge at least shall show but slight kiln marks. Brick so distorted as to lay unevenly in the work will be rejected.

The standard size of vitrified paving block shall be three and one-half (3½) inches in thickness, four (4) inches in depth, and eight and one-half (8½) inches in length. The brick shall have one reasonably straight face and shall not vary from these dimensions more than one-eighth (⅛) of an inch in width or depth, nor more than one-half (½) inch in length. If the edges of the brick are rounded, the radius shall not exceed three sixteenths (3/16) inch.

The brick shall not lose more than twenty (20) per cent of their original weight when subjected to the Rattler test. (American Society for Testing Materials Specification, Serial Designation C-7.)

Brick shall be subject to thorough inspection before and after laying and rolling and all rejected material shall be immediately removed from the work.

The Contractor must submit with his proposal, a sample of the paving brick which he proposes to use, for approval by the Engineer. All brick used must be equal to the approved sample.

6. Sand (Pavements and Floors)

The sand for the cushion shall be clean, sharp, hard, durable, uncoated particles preferably of a silicious nature, free from clay, organic matter, shale or alkali. No particle shall exceed one quarter inch (¼") in maximum grain size. The sand may contain material passing a No. 20 standard mesh sieve not exceeding fifteen (15) per cent by weight of the total.

7. Asphalt Filler (Pavements and Floors)

Unless otherwise specifically permitted in the contract, all filler shall be asphalt cement, which complies with the specifications of the American Society for Testing Materials, Serial Designation D-241.

8. Cement Grout Filler (Pavements and Floors)

When specifically permitted by the contract cement grout filler may be used instead of the asphalt filler. The cement shall comply with the requirements of the American Railway Engineering Association's "Specifications for Portland Cement."

The sand shall consist of clean, hard, strong, durable, uncoated particles, preferably of a silicious nature, free from clay, organic matter, shale or alkali and comply with the following grading requirements:

Passing 10 mesh sieve	100 per cent
Passing 20 mesh sieve, not less than	75 per cent
Passing 50 mesh sieve, not more than	30 per cent
Passing 100 mesh sieve, not more than	10 per cent

9. Expansion Joints (Pavements)

When cement grout filler is used, an expansion joint of bituminous material shall be placed parallel with and adjacent to the curb line or tracks, around all obstructions in the paving, transversely across the paving points of change in grade or alignment and at the points of curvature of the curb line at all intersecting pavements.

The bituminous filler for the expansion joints shall consist of a mixture of sixty-five (65) per cent asphalt filler, fifteen (15) per cent coal tar pitch filler and twenty (20) per cent Portland cement. The asphalt and Portland cement shall be as specified hereinbefore and the coal tar pitch shall comply with the specifications of the American Society for Testing Materials for Coal Tar Pitch, Serial Designation D-112.

9. Expansion Joints (Floors)

When cement grout filler is used, an expansion joint of bituminous material shall be placed around the walls and columns and all other obstructions in the flooring.

The bituminous filler for the expansion joints shall consist of a mixture of sixty-five (65) per cent asphalt filler, fifteen (15) per cent coal tar pitch filler and twenty (20) per cent Portland cement. The asphalt and Portland cement shall be as specified hereinbefore and the coal tar pitch shall comply with the specifications of the American Society for Testing Materials for Coal Tar Pitch, Serial Designation D-112.

CONSTRUCTION

10. Laying the Cushion (Pavements and Floors)

Unless otherwise specifically permitted in the contract, the cushion shall be of bituminous mastic.

(a) Bituminous Mastic Cushion. Upon the concrete foundations shall have been finished to within one-half inch (½″) of the grade for the bottom of the brick and which shall have been thoroughly cleaned and dried, shall be spread a layer of mastic, not exceeding three-quarters of an inch (¾″) in thickness. The mastic shall consist of ten (10) per cent of the asphalt filler and ninety (90) per cent of sand as specified hereinbefore. The mastic shall be heated to a temperature of not less than 325 degrees Fahr. nor more than 350 degrees Fahr. and thoroughly mixed so that all grains of sand are completely coated. The mastic shall be spread while hot and struck by templates to a surface parallel to the grade and contour of the finished surface. This cushion shall be spread a day in advance of the laying of the brick.

When specifically permitted by the contract, cement mortar cushion may be used instead of bituminous mastic cushion.

(b) Cement Mortar Cushion. Upon the concrete foundation, which shall have been finished to within one-half inch (½″) of the grade for the bottom of the brick and which shall have been thoroughly cleaned and dried, shall be spread a layer of thoroughly mixed dry mortar, not exceeding three-quarters of an inch (¾″) in thickness. The mortar shall consist of one (1) part of Portland cement and three (3) parts of sand both as specified hereinbefore for curb and gutter in Article 4. Only sufficient water shall be added to this mixture to insure a proper setting of the cement, so that a granular mixture will be produced which may be raked to the desired grade. The mortar shall be spread in place on the foundation immediately in advance of the laying of the bricks. The mortar shall be raked to the approximate grade and uniform density and struck off by template to a surface parallel to the grade and contour of the finished surface.

When specifically permitted by the contract, sand cushion may be used instead of bituminous mastic cushion.

(c) Sand Cushion. Upon the concrete foundation, which shall have been finished to within one-half inch (½″) of the grade of the bottom of the brick and which shall have been thoroughly cleaned and dried shall be spread a layer of sand as specified hereinbefore, not exceeding three-quarters of an inch (¾″) in thickness. The sand shall be spread in place immediately in advance of the laying of the bricks. The sand shall be raked to the approximate grade and uniform density and struck off by a template to a surface parallel to the grade and contour of the finished surface. The sand cushion shall not be disturbed after striking off prior to laying the brick.

11. Laying Paving Brick (Pavements)

The pavement shall be laid upon the above specified bituminous mastic, cement mortar or sand cushion in a single layer of brick on edge, end to end and at right angles to the center line of the thoroughfare except at intersections where the courses shall be laid at such angles as the Engineer directs. All brick laying and conveying of brick shall take place over brick already laid and shall follow the completion of the cushion within fifty feet (50′). The better face or wire cut side shall be laid up and lugs, if any, shall be turned in one direction. Alternate courses shall begin with one-half a brick and where necessary shall be completed by batting at the ends with bats not less than three inches (3″) long, a portion of the adjoining brick being broken off if necessary to give the minimum three inch (3″) bat at the end of the course. The fractured end of cut or trimmed brick shall be turned toward the center of the pavement. Every course shall be laid true and even, perpendicular to the center line of the pavement and no course shall deviate from a straight line more than two inches (2″) in thirty feet (30′). The bricks in adjacent courses shall break joints at least two inches (2″). The Contractor may be required to lay every tenth (10th) course to a line. The bricks shall be set perpendicular to the grade and to a height from one-quarter inch (¼″) to three-quarters inch (¾″) or such other height as the Engineer may direct above the true finished grade of the pavement to provide settlement in tamping and rolling.

When the curvature of the alignment of the pavement permits, the brick shall be laid in radial courses allowing at the outside of the curve a space between courses not exceeding one-half inch (½″). When the curvature exceeds this, the brick shall be laid in radial courses transversely across the roadway and in the intervening space between the courses the brick shall be laid longitudinally at right angles to one of the transverse courses of each successive closure. No portion of a brick less than three inches (3″) in length shall be used for batting such closures and the amount of space batted shall not exceed a whole brick, by varying the length of the successive transverse courses. In no case shall brick be split longitudinally to make a closure on a curve.

11. Laying Flooring Brick (Floors)

The flooring brick shall be laid upon the above specified bituminous mastic, cement mortar or sand cushion in a single layer of brick on edge, end to end and at right angles to the center line or axis of the building. All brick laying and conveying of brick shall take place over brick already laid and shall follow the completion of the cushion within fifty feet (50′). The better face or wire cut side shall be laid up and lugs, if any, shall be turned in one direction. Alternate courses shall begin with one-half a brick and where necessary shall be completed by batting at the ends with bats not less than three inches (3″) long, a portion of the adjoining brick being broken off if necessary to give the minimum three inch (3″) bat at the end of the course. The fractured end of cut or trimmed brick shall be turned toward the center axis of the building. Every course shall be laid true and even, perpendicular to the axis of the building and no course shall deviate from a straight line more than one-half inch (½″) in ten feet (10′). The bricks in adjacent courses shall break joints at least two inches (2″). The Contractor may be required to lay every tenth (10th) course to a line. The brick shall be set perpendicular to the grade and to a height from one-quarter inch (¼″) to three-quarter inch (¾″) or such other height as the Engineer may direct above the true finished grade of the floor to provide settlement in tamping and rolling.

12. Tamping and Rolling (Pavements)

Immediately after the brick are laid, the surface of the pavement shall be swept and inspected. Brick not laid with the better or wire cut face or side upward shall be turned over. All broken, injured and defective brick shall be replaced. Brick slightly chipped but otherwise acceptable may be used. The surface of the pavement shall then be tamped and rolled. The roller shall weigh not less than three (3) tons nor more than five (5) tons. The brick at the edge of the pavement or next to the curb shall be tamped with a tamper weighing not less than fifty pounds (50 lb.). A plank not less than six feet (6′) long, from ten inches (10″) to twelve inches (12″) wide and two inches (2″) thick shall be interposed between the pavement and the tamper and moved about so that the entire surface near the edge of the pavement or curb shall be thoroughly and equally tamped and the surface brought to the proper grade. The rolling shall then begin at the edge of the pavement or at the curb at a very slow pace and continue backward and forward until the center of the pavement is reached, then passing to the opposite edge or curb and working in like manner back to the center of the pavement. After this first passing of the roller, the pace may be quickened. The rolling shall continue until each brick is firmly embedded in the cushion. The pavement shall then be rolled transversely at an angle of forty-five

(45) degrees from curb to curb, repeating the rolling in the opposite direction at the same degree of angle. After this transverse rolling, all broken, injured and defective brick shall be replaced with perfect ones which shall be brought to the true surface by tamping.

When the rolling and tamping is completed, the surface of the pavement shall conform so truly to the designed datum that it will nowhere depart more than five-sixteenths ($\frac{5}{16}$") from properly formed templates and straight edges applied to its surface except where pavement is sloped to provide drainage to catchbasins, drains, etc.

12. Tamping and Rolling (Floors)

Immediately after the brick are laid, the surface of the floor shall be swept and inspected. Brick not laid with the better or wire cut face or side upward shall be turned over, those not meeting requirements for quality or which are damaged shall be replaced. Brick slightly chipped, but otherwise acceptable may be used. The surface of the floor shall then be tamped or rolled. If the size of the building makes rolling impracticable, the floor shall be tamped with a tamper weighing not less than fifty pounds (50 lb.). A plank not less than six feet (6') long, from ten inches (10") to twelve inches (12") wide and two inches (2") thick shall be interposed between the floor and the tamper and moved about so that the entire surface shall be thoroughly and equally tamped and the surface of the floor brought to the proper grade.

The rolling shall be done with a roller weighing not less than three (3) tons nor more than five (5) tons. The rolling shall begin as near the wall as possible, the portion of the floor where rolling is impossible being tamped. The rolling shall begin at a very slow pace longitudinally backward and forward until the center of the building is reached, then passing to the opposite wall and working in like manner back to the center of the building. After this first passing of the roller, the pace may be quickened. The rolling shall continue until each brick is firmly embedded in the cushion. The floor shall then be rolled transversely at an angle of forty-five (45) degrees from side to side of building and repeating the rolling in the opposite direction at the same degree of angle. After this transverse rolling, all broken, injured and defective brick shall be replaced with perfect ones which shall be brought to the true surface by tamping.

When the tamping and rolling is completed, the surface of the floor shall conform so truly to the designed datum that it will nowhere depart more than five-sixteenths inch ($\frac{5}{16}$") from properly formed templates and straight edges applied to its surface except where floor is sloped to fit drainage to catchbasins, drains, etc.

13. Applying Asphalt Filler (Pavements and Floors)

Immediately before filling the joints, surface of the brick shall be swept clean. All brick shall be clean and dry when filler is applied. Filler shall not be applied when brick are wet nor if air temperatures are such that the filler will not flow freely into the joints.

Filler shall be heated to a temperature not exceeding 350 degrees Fahrenheit. It shall be applied at a temperature of not less than 325 degrees Fahrenheit. The heater shall be equipped with a thermometer capable of registering the temperatures of the filler at all times. The filler shall be flooded over the surface of the brick by means of buckets or cans and while still hot the filler shall be moved back and forth with heated squeegees until the joints are filled.

Immediately after the joints are filled, a thin coating of dry stone screenings, sand or granulated slag shall be spread upon the surface of the brick. Top dressing shall be of such sizes that all will pass a number 4 standard mesh sieve. As soon as the dressing is spread, the surface of the brick shall be rolled thoroughly to bed the dressing into the excess bituminous coating.

The work may be used immediately upon completion of the surface dressing, but said surface dressing shall not be swept off for at least four (4) days.

14. Applying Cement Grout Filler (Pavements and Floors)

The joints between the brick shall be completely filled with cement grout composed of one (1) part of cement to one and one-half (1½) parts of sand measured by volume.

The sides and ends of the brick shall be wet by gentle sprinkling immediately before the joints are filled.

The sand and cement shall be mixed dry in a mechanical batch mixer until the mass attains a uniform shade. Sufficient quantity shall be so mixed that a continuous supply will be available during the operation of the grouting. A small batch not more than two (2) cubic feet of the prepared dry mixture shall then be placed in a watertight box and sufficient water added and mixed to produce the consistency of mortar. Water shall then be gradually added, continuing the operation of mixing until the whole reaches such consistency that it will readily flow to the bottom of the joints without separation of the ingredients.

The filler shall be removed from the box to the surface of the brick and applied until the joints are filled. Filler shall be swept immediately into the joints, making certain they are filled to the bottom. During the process of applying the filler, that remaining in the mixing box, shall be constantly agitated in order that the proper consistency and proportions may be maintained.

After allowing a sufficient time for the filler to settle in the joints, but before it takes its initial set, a second application of a somewhat thicker consistency shall be mixed and spread in same manner, as first. The filler shall be swept into the joints by means of squeegee having rubber edges which shall be worked at an angle to the joints. Successive applications of the filler shall be made as provided, until the joints remain completely filled flush with the surface of the brick.

When a mechanical grout mixer is used, in preparing and applying the filler, it shall be of the batch type, self contained and portable, and shall be of such construction and operation that the surface of the brick shall not become splashed with oil or water. The prepared filler shall be delivered from the mixer to the pavement surface in such manner that there shall be no separation of cement and sand in transit or in place.

The Contractor shall provide metal strips one-sixteenth inch in thickness, six (6) inches in depth, and three (3) feet in length, which shall be inserted in a transverse joint in the brick before closing the grouting of each work interval in order that the grouting shall end in a vertical joint. The strips shall remain in place until the filler has developed its initial hardening and be removed before the final hardening shall have occurred.

After the brick have been inspected and approved and sufficient time has elapsed to avoid injury to the filler, a protective covering of sand or earth not less than one (1) inch in depth shall be spread upon the surface of the brick. This shall be kept wet for a period of not less than four (4) days. This covering shall be removed by the Contractor at the completion of the work.

The work shall not be used for at least fifteen (15) days after cement grout filler is completed.

15. Applying Expansion Joint Filler (Pavements and Floors)

When cement grout filler is used expansion joints shall be constructed by placing one and one-half inch (1½″) boards in the work between the rows of brick at the points required. The brick shall be firmly laid against these boards which shall remain in place until the bricks are rolled and immediately preceding the application of the filler as hereinbefore specified, they shall be carefully removed without disturbing the adjacent bricks.

When the planks have been removed, the space shall be filled with the bituminous cement composed of the ingredients specified hereinbefore and mixed and prepared as follows:

In preparing this bituminous cement, the pitch shall first be melted and the asphalt, also melted, added and thoroughly incorporated by agitation. The hydraulic cement shall then be added and the whole agitated until a complete and uniform mixture results. The bituminous cement thus prepared shall be, while sufficiently hot and liquid to flow freely, poured from a spouted vessel into the joints until they appear to be nearly or quite full. After allowing time for the filling to subside, the joints shall be gone over a second time and completely filled, care being taken to confine the cement to the joints and not to deposit it on the surface of the brick.

16. Adjusting Existing Structures (Pavements)

Manholes and catchbasin covers, valve boxes and similar existing structures within the area to be paved shall be adjusted by the Contractor to come flush with the pavement surface.

17. Guaranty (Pavements and Floors)

It is hereby understood and agreed that the Contractor shall guarantee the material furnished and used and the workmanship employed in the construction of the work, to be of such quality and character as to insure the same to be free from all defects, and to remain in continuous good order and condition satisfactory to the Engineer for a period of one year. The guarantee shall include all repairs to be made or, if necessary, the entire reconstruction of the work, as the Engineer may direct, without additional charge or cost to the Railroad Company.

18. General Conditions (Pavements and Floors)

All materials entering into this work and all methods used by the Contractor shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all the work is completed and accepted.

The general conditions as given in Section 1 of this specification shall be considered to apply with equal force to this specification.

SECTION 27

Sprinkler System

DRY PIPE, WET PIPE OR DELUGE SYSTEM

1. General

Sprinkler system to be installed under this contract shall consist of the furnishing and installing of a sprinkler system complete as herein described.

2. Checking Drawings

The Contractor shall check all drawings and must report all discrepancies before starting the work. No allowances will be made for errors or discrepancies discovered by the Contractor after the work has been started.

The Contractor shall submit a layout of the system showing the number of heads and approved by the Underwriters. This layout must be approved by the Engineer before work is started.

3. Laying Out Work

Dimensions on drawings shall be verified at the site of the work by the Contractor and he shall assume all responsibility for their accuracy.

4. System

The sprinkler system to be used will consist of what is known as a
Dry Pipe System,
Wet Pipe System, same to be designed and installed in accordance with the
Deluge System,
rules and regulations of the Underwriters having jurisdiction in territory in which the sprinkler system is to be installed.

5. Piping System

The system of piping shall be best suited to the building in which the sprinkler system is to be installed.

If it is necessary to divide the sprinkler system into a number of sections, each section shall be provided with an indicating control valve to be situated in suitable location. Each section shall also be provided with drains to enable the sections to be drained if found necessary. The ends of piping *must* be reamed in order to remove burrs and fins, also the threads on the piping shall be cut to provide a good joint. The piping shall not extend into the fittings to such an extent as to restrict the flow of water. Piping shall be made up in place. The assembly of piping on the ground prior to its being hung will not be allowed on account of the possibility of straining fittings. Piping shall be straight, and Contractor will be required to replace any piping that is likely to cause any pockets. Connections to supply mains are not to be made until Contractor has flushed out supply main, and is assured that there is no foreign matter in the line that may cause any stoppage or foul in sprinkler heads.

6. Pipe Hangers and Supports

Piping shall be firmly and neatly secured on suitable hangers or supports, properly spaced. These hangers or supports shall be the best adapted to conditions found in the building, and shall make a good appearing and substantial job. The use of perforated bar or strap hangers will not be permitted. Vertical risers shall be substantially supported in an approved manner. Contractor, when submitting his layout for approval, shall submit details of all hangers for the approval of the Engineer.

7. Control and Drain Valves

Control valves in the system shall be of the outside screw and yoke type gate valve of proper weight to withstand the water pressure to be carried on the system. Drain valves in system shall be gate type of proper weight and design to withstand water pressure carried on system. Each valve shall be plainly marked to designate service.

8. Automatic Control Valves

Automatic control valve or valves for the Dry Pipe System,
Wet Pipe System,
Deluge System, shall be installed in a suitable and accessible location in the building. If it is necessary to install the valve or valves in location where the temperature will fall below 32 degrees Fahr., necessary precautions shall be taken to frost-proof all equipment exposed to low temperatures.

9. Air Supply

Air supply for automatic valve will be furnished from existing compressed air distribution system or independent air compressor, as specified. If independent air compressor is to be used, Contractor shall state in his proposal the size, capacity, manufacturer's name and catalog description of air compressor upon which his proposal is based. If compressed air distribution system is available, Contractor shall install piping between source of supply and sprinkler system. Air supply shall be taken from point indicated on drawings.

10. Sprinkler Heads

Sprinkler heads used in this installation shall be constructed for the temperature best suited for the protection of the building. They shall be of the soldered link or quartz bulb type. They shall not be installed until the piping is installed in place. Sprinkler heads shall be applied with special wrenches provided by the manufacturer, and the Contractor shall use every precaution against damaging the sprinkler heads during installation. Sprinkler heads shall be provided with guards wherever necessary. Cabinet with extra sprinkler heads and special wrenches shall be provided in accordance with Underwriters' requirements.

11. Source of Water Supply

The water to be used in sprinkler system shall be obtained from
Underground Mains,
House Tank,
Elevated Tank,
and the Contractor shall make the necessary connection or connections to source of supply where indicated on drawings. Contractor shall install at each point where connection is made an indicating outside screw and yoke type gate valve. He shall also provide necessary test connection, strainers, check valves, clean-out and flushing connections, etc., required by the Underwriters.

12. Thimbles and Sleeves

Where pipes pass through floors or run through partitions, suitable thimbles or sleeves shall be installed in such a manner as will prevent leakage to the floor below.

13. Post Indicator Valve or Valves

The Contractor will be required to install Post Indicator Valves in supply lines at points requiring same. The Post Indicator Valve shall comply with requirements of the Underwriters, and be designed so that the valve will close when valve stem is turned in a clockwise direction, except where fire protection equipment is equipped with valves which operate in the opposite direction, in which case the prevailing practice shall govern. The operating nut on valves installed shall conform in design to existing equipment or local municipal equipment, so that one size wrench can be used on all fire fighting apparatus.

14. Electric Wiring

Electric wiring required in connection with the installation of sprinkler system shall conform to the rules and regulations of the National Code. All wiring shall be installed in conduit.

15. Cutting Walls, Floors and Partitions

The Contractor will be required to do all cutting in connection with this installation to allow for the passage of pipe through walls, floors, etc. He will also be required to repair any damage done by him during the course of work. If this damage is not repaired promptly, repairs may be made at the expense of the Contractor.

16. Fire Department Connection

Fire Department connection shall be provided if specified. This connection shall be of required size and conform to the requirements of the Underwriters.

17. Material

Inside pipe used in connection with this installation shall be new
Strictly Genuine Wrought Iron Black Pipe
Strictly Genuine Wrought Iron Galv. Pipe
Mild Steel Black Pipe, as made by . ... of ....,
Mild Steel Galv. Pipe
or approved equal. Cast iron pipe shall be new and of class required by Underwriters. Valves shall be outside screw and yoke type as manufactured by .... of ...., or approved equal. Fittings shall be of fine grain, gray cast iron of .... make, of ...., or approved equal, with threads clean-cut, tapering and smooth. Thread joints shall be iron to iron without the use of red lead or cement. All flanged fittings shall be made with packing or gaskets of .... make, of ...., or approved equal. Cast iron pipe shall be laid in conformity with rules and regulations of the Underwriters having jurisdiction. Materials used in connection with this installation shall be the best of their respective kinds, and put together by skilled mechanics under competent supervision. Contractor shall state make of equipment he proposes to furnish, and no substitution will be allowed from those mentioned in the proposal.

18. Preliminary Tests and Cleaning

The Contractor will be required to make a preliminary test of the system to ascertain whether there are any leaks in the piping, also remove all sediment, rust and dirt out of the piping system. Each supply main shall be thoroughly flushed and water is not to be turned into the sprinkler system until the water is clear.

19. Tests

The Contractor shall conduct the test required on the sprinkler equipment in the presence of representatives of the Company and of the Underwriters having jurisdiction. Equipment required to make test shall be furnished by this Contractor. Sprinkler system will be accepted only after all leaks and defects have been repaired and all the conditions of these specifications and the requirements of the Underwriters have been satisfactorily complied with. Contractor shall furnish a complete set of written instructions, neatly framed and glazed, covering the operation of the system, for reference purposes.

20. Painting

All equipment and piping installed in connection with sprinkler system shall be painted with two coats of lead and oil paint. Make and color of paint to be used subject to the approval of Engineer.

21. Guarantee

Contractor must guarantee the perfect operation of the system heretofore described that it will be capable of fulfilling the requirements of the Underwriters having jurisdiction. Any omission in these specifications or the drawings accompanying same do not relieve the Contractor of fulfilling his obligations to install the system complete in every respect, and fulfill his guarantee.

22. Cleaning

At the completion of the work, the Contractor shall remove all construction equipment, scaffolding, staging, erection platforms and all surplus material from the premises, leaving the premises in a clean and acceptable condition. If any equipment or debris is not removed promptly, such material may be removed at the expense of the Contractor.

23. General Conditions

All materials entering into the work and all methods used by the Contractor shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all of the work is completed and accepted.

The general conditions given in Section No. 1 of this specification shall be considered to apply with equal force in this section of the specification.

Appendix F

(6) WHAT CONSTITUTES APPRAISAL OF FIRE LOSSES

G. A. Rodman, Chairman, Sub-Committee; A. C. Copland, E. W. Everett, W. L. Lozier, F. L. Riley

Questionnaire was prepared and sent out to the Chief Engineer, or other ranking official, of all roads represented by the Association. So far replies have been received from fifty-two roads. Some of these replies did not fill out the questionnaire at all; simply advised that they either had no information to give or made some evasive reply. Out of the replies some thirty roads are covered wholly or in part by outside insurance companies, twenty-three wholly or in part by insurance funds of their own, six protected by mutual companies.

It is hoped that further replies will be received and the intention is to tabulate these replies and make a complete formula of the results, with recommendations of the Committee.

It is therefore recommended that this subject be reassigned for further study.

REPORT OF COMMITTEE XI—RECORDS AND ACCOUNTS

J. H. HANDE, *Chairman;*
E. Y. ALLEN,
B. A. BERTENSHAW,
A. M. BLANCHARD,
R. R. L. BULLARD,
E. S. BUTLER,
E. B. CRANE,
F. P. FUNDA,
T. H. GREENE,
C. R. HARTE,
W. E. HEIMERDINGER,
W. A. HILL,
ALFRED HOLMEAD,
W. R. KETTENRING,
C. A. KNOWLES,
C. C. HAIRE, *Vice-Chairman;*
HENRY LEHN,
W. T. MEAD,
E. W. METCALF,
C. OBERDORF,
J. T. POWERS,
C. K. SMITH,
JAMES STEPHENSON,
V. R. WALLING,
G. R. WALSH,
JOHN W. WEBSTER,
H. R. WESTCOTT,
A. P. WEYMOUTH,
LOUIS WOLF,

Committee.

To the American Railway Engineering Association:

Your Committee on Records and Accounts respectfully presents herewith its annual report covering the subjects assigned, as follows:

(1) Revision of Manual (Appendix A).

(2) Collaborate with other Committees in the preparation and design of forms pertinent to their work (Appendix B).

(3) Report progress upon changes or revisions in I.C.C. Classification of Accounts (Appendix C).

(4) Study and report progressively upon methods and forms for gathering the necessary data for keeping up to date the physical and valuation records of the property of railroads with respect to:

(a) Changes made necessary in government regulations.

(b) Simplicity and practicability of use (Appendix D).

(5) Report upon methods and forms for handling the Interstate Commerce Commission's requirements under Order 15100—Depreciation Charges of Steam Railroad Companies (Appendix E).

(6) Study statistical requirements of the accounting, operating or other departments with respect to maintenance of way and structures, and recommend reports for maintenance foremen which as far as possible will reduce the number required and permit uniformity, simplicity and economy (Appendix F).

(7) Outline of work for ensuing year (Appendix G and Recommendations for future work).

Action Recommended

The Committee recommends that as to

Assignment 1: The report be accepted as information.

Assignment 2: Sections (a) and (c) of report be accepted as information, and that the specifications for forms in Section (b) be adopted and published in the Manual.

Assignment 3: The report be accepted as information.

Assignment 4: The report be accepted as a progress report.

Assignment 5: The report be accepted as a progress report.

Assignment 6: The report be accepted as information, and that the form recommended be adopted for publication in the Manual.

Assignment 7: The report be accepted as information.

Recommendations for Future Work

1. Revision of Manual.

2. Report progress upon changes or revisions in I.C.C. Classification of Accounts.

3. Study and report progressively upon methods and forms for gathering the necessary data for keeping up to date the physical and valuation records of the property of railroads with respect to:

(a) Changes made necessary in government regulations.

(b) Simplicity and practicability of use.

4. Report upon methods and forms for handling the Interstate Commerce Commission's requirements under Order 15100—Depreciation Charges of Steam Railroad Companies.

5. Study statistical requirements of the accounting, operating or other departments with respect to maintenance of way and structures, and recommend reports which as far as possible will reduce the number required and permit uniformity, simplicity and economy.

6. Report upon methods and forms (a) for maintaining a record of railway, highway and private grade crossings, and (b) for making annual reports of grade crossings added or eliminated, collaborating with Committee IX—Grade Crossings.

7. Collaborate with Committee XXII—Economics of Railway Labor in the preparation of standard forms on which data relative to labor saving devices may be kept.

8. Collaborate with Committee XII—Rules and Organization in the design of Bridge Inspection Report Form.

9. Study and report upon accounting for industry tracks in its relation to ownership and contract provisions.

10. Current periodical and book review.

11. Outline of work for ensuing year.

Respectfully submitted,

THE COMMITTEE ON RECORDS AND ACCOUNTS,

J. H. HANDE, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

John T. Powers, Chairman, Sub-Committee; C. A. Knowles, W. T. Mead, Calvin Oberdorf and James Stephenson.

A new edition of the Manual has been in course of preparation. The Sub-Committee has read and compared the proof sheets of Committee XI's section. The Committee offers no recommendation for revision this year.

Appendix B

(2) COLLABORATE WITH OTHER COMMITTEES IN THE PREPARATION AND DESIGN OF FORMS PERTINENT TO THEIR WORK.

E. Y. Allen, Chairman, Sub-Committee; R. R. L. Bullard, E. B. Crane, F. P. Funda, T. H. Greene, C. R. Harte, W. E. Heimerdinger, W. A. Hill, E. W. Metcalf, J. T. Powers, C. K. Smith, V. R. Walling, A. P. Weymouth.

This assignment was first made last year, and having taken care of collaborations with certain other committees on specific phases of their assignments, your Committee has given consideration to its scope and field of activity with a view to determining the points of contact with the work of other committees so as to outline clearly the best methods by which to regulate its collaborations.

With that in mind, this year's assignment has been divided into three sections:

(a) Check the list of forms and records reported last year as required in the several branches of the Engineering Department in their routine operations, and recommend others that should be added to that list.
(b) Develop general specifications to which forms submitted in collaborations and developed by Committee XI should conform.
(c) Specific collaborations with other committees.

Reports are made under these three sections as follows:

(a) Check the list of forms and records reported last year as required in the several branches of the Engineering Department in their routine operations, and recommend others that should be added to that list.

On pages 761 to 765 of Bulletin 304, February, 1928, this Committee presented a list, arranged under the general classifications of (A) Design and Construction Department; (B) Maintenance Department, and (C)

Valuation Department, of all the forms used in routine railway operations which were included in the 1921 Manual and subsequent Bulletins. It is the purpose of this Committee to compile a list of other records or reports used in routine railway operations, included under the above general classifications, for which forms should be designed and included in the Manual. Therefore, there is offered this year the following:

FORMS TO BE DESIGNED AND INCLUDED IN THE MANUAL

(A) Design and Construction Department

Position Originating Form	*Title of Form*
Construction Inspector	Report of Time and Distribution of Labor and Equipment for Force Account or Percentage Contracts.
Chief Engineer	Annual Report of Increase or Decrease of Track Mileage.
Chief Engineer	Record of Railway, Highway and Private Grade Crossings.
Chief Engineer	Annual Report of Grade Crossings Added or Eliminated.

(B) Maintenance Department

Bridge Engineer	Bridge List.
Bridge Engineer	Record of Second-hand Structural Steel on Hand.
Chief Engineer Maintenance of Way	Monthly Report of Cross Ties Renewed.
Chief Engineer Maintenance of Way	Annual Program of Repairs and Renewals to Bridges.
Chief Engineer Maintenance of Way	Annual Program of Repairs and Renewals to Buildings.

(C) Valuation Department

The recommended additions do not touch upon forms to be used in the Valuation Department, inasmuch as these forms are being considered under other assignments in last year's and this year's report.

(b) Develop general specfications to which forms submitted in collaborations and developed by Committee XI should conform.

In the work of collaboration with other committees and in the design of forms by this Committee, it is evident that the work could proceed with more unformity if there were adopted general specifications to which the forms thus designed should conform. For this purpose, there have been prepared specifications for designing forms, and included therewith also brief specifications for printing, paper, etc. These are submitted and recommended for inclusion in the Manual.

SPECIFICATIONS FOR THE DESIGN, ARRANGEMENT AND PRINTING OF FORMS

Purpose of Forms

(1) The purpose of a form is to provide a convenient means for recording facts or statements in a systematic manner.

General Requirements

(2) Forms should be made as simple as possible so that they may be readily understood and easily filled out. No more information should be called for than is absolutely required.

Temporary or Permanent Forms

(3) Forms may be for temporary use or permanent record. Temporary forms do not always require as complete data and may be printed on cheaper paper.

Form Number

(4) Each form should be given a number. This number should be printed in small type in one top corner—left preferred.

Name of Carrier

(5) The name of the carrier should be printed on permanent forms and on temporary forms which pass from one department to another.

Office Originating Report

(6) Designation of the office originating the report or statement should be shown, such as "Office of (title), (location)." This should appear below the name of the carrier.

Caption of Form

(7) The heading or caption of the form should indicate the character of the report or the statement and should appear in large type. This should follow the words indicating where the report or statement was made.

Headings and Column Captions

(8) It is important that the title or heading of the form and the column headings also be clearly and briefly stated, so that the person filling out the form will understand what information is wanted.

Column and Line Spacing

(9) Column widths should be made with respect to the figures and for the wording to be filled in. Column and line spacing should be arranged for typewriter or handwriting.

Column and Line Numbering

(10) For the larger and more complicated forms, it is desirable to number each vertical column and each horizontal line. The column numbers should be placed immediately below the caption of the column and the line numbers at both ends of the line.

Guide Lines

(11) On many forms, it is desirable to rule every third or fifth line heavier or a different color.

Prepared and Approved by

(12) Where desirable, forms should provide spaces in a suitable place, such as the lower right corner, similar to:

Compiled by .... Date 193
Checked by .... Date 193
Approved by .... Date 193

Sheet Numbering

(13) When more than one sheet is required for a report, space should be provided, preferably in upper right corner, to show the number of sheets in the series, such as

Sheet .... of .... sheets.

Binding Margin

(14) It is desirable to leave at least 1¼" on the side intended for binding.

Printing Instructions for Filling Out Forms

(15) Instructions for filling out forms may be on a separate sheet, or printed on the back or at the bottom of the face of the form. If the form is to be available for blueprinting, as provided for in paragraph (20), the instructions should not be printed on the back. When there may be doubt as to the manner in which entries should be made, the instructions should include a sample form wholly or partially filled out with typical entries clearly illustrating its use, or a form on which there has been printed in the columns or on the lines the instructions for filling out the specific column or line.

Size

(16) Each carrier should adopt a standard size and all forms should be either this standard size or multiples thereof. The size to be adopted should be such that there is no wastage in cutting and should also fit standard filing cabinets. The standard sizes of paper which may be cut to the best advantage are as follows:

	Inches		*Inches*
Cap	14 x 17	Folio	17 x 22
Double Cap	17 x 28	Double Folio	22 x 34
Double Double Cap	28 x 34	Medium	18 x 23
Crown	15 x 19	Double Medium	23 x 36
Double Crown	19 x 30	Royal	19 x 24
Demy	16 x 21	Double Royal	24 x 38
Double Demy	21 x 32		

Color of Lettering and Lines

(17) Where lettering and lines are printed (not ruled) one color (black preferred) should be specified. Spaces or sections may be separated by a heavier or a double thin black line rather than by a colored line. When the lines are pen ruled, different colored lines may be used, such as red and blue on white paper and brown and green on buff paper.

Punching

(18) When intended for a loose leaf binder, consideration should be given to punching or making the places for the binding holes to fit the binders intended to be used. When the type of binder to be used is known, the forms should be pre-punched. This will facilitate filing.

Quality and Weight of Paper

(19) Paper is made from two basic substances, namely, rags or wood pulp. Wood pulp paper is suitable only for inter-office or temporary forms. Forms for permanent record should be printed on paper with rag content of thirty per cent or better. The paper should be durable and tough and flexible enough to crease without cracking. It should be of a grade which will not fade or turn yellow with age and should stand several erasures without allowing the ink to show through on the reverse side. The weight of the paper should receive consideration as economies may be effected through preparation at one writing of sufficient copies to complete the records in all offices requiring the report. In this connection it may be pertinent to quote paragraph 1741 appearing on page 518 of the 1928 edition of "Railway Accounting Procedure" published by the Railway Accounting Officers' Association.

> "It has been found that railroads do not avail themselves of the economies which are practiced in many other lines of business, through the preparation at one writing of a sufficient number of copies of essential reports to complete the records in all offices in which the information contained in the reports is required or is filed. Economies which may be effected by more general use of copies of original reports are suggested to all railroads."

Blueprint Reproductions

(20) It is well to anticipate that some reports or statements made on forms may be reproduced by blueprinting. In such cases consideration should be given to the kind of paper and the instructions should provide that, when typing, black carbon paper, reversed, should be laid against the reverse side. The typewriter ribbon used should be black record.

Methods of Printing

(21) The principal methods of printing are as follows:

1. Mimeograph
2. Multigraph
3. Printer's type and printed lines
4. Printer's type and pen ruling
5. Hand lettering and lithographic printing or photo-printing from zinc and copper plates.

Economy in printing can often be obtained by group printing. Under this procedure, several different forms are run through the press and printed at the same time on large sheets or rolls of paper which are afterward cut to the required size for each form.

Padding Forms

(22) To avoid wastage through soiling or wrinkling, forms which are in frequent use should be made up in pads of fifty or one hundred sheets.

Cards

(23) Cards are sometimes preferable to sheets for permanent records. Use should be made of standard stock sizes where practicable, such as:

3″ x 5″; 4″ x 6″; or 5″ x 8″

Because many cards are subjected to much "fingering" they should be of good quality rag content. The use of celluloid tab covers or guides is recommended to protect the parts of the cards most subject to wear. Specifications for paper forms referred to in other parts of this report should also be considered when designing printed and/or ruled cards.

A Forms Committee on Each Railroad

(24) It is recommended that each carrier establish its own "forms committee," which committee should have authority to design and/or approve all new forms or changes in established forms.

(c) Specific Collaborations with other Committees

There was in progress this year collaboration with only one other standing committee, namely, Committee XII, upon the preparation of bridge inspection forms. That collaboration has been proceeding, but has not been completed up to the time of filing this report.

Letters were addressed to the Chairman of each standing and special committee, inquiring as to what collaborations were desired in connection with the design of forms. Replies were received, indicating that this year not one of these committees was contemplating the design or preparation of any form.

Conclusion

Your Committee makes the following recommendations:

(a) That the list of forms to be designed be received as information.

(b) That the "Specifications for the Design, Arrangement and Printing of Forms" be adopted and published in the Manual.

(c) That the collaboration with Committee XII be continued.

Appendix C

(3) REPORT PROGRESS UPON CHANGES OR REVISIONS IN I.C.C. CLASSIFICATION OF ACCOUNTS

H. R. Westcott, Chairman, Sub-Committee; C. R. Harte, Alfred Holmead, J. W. Webster.

This report is submitted in response to the assignment to your Committee, and is a continuation from November 9, 1927, of the report prepared last year and printed in A.R.E.A. Bulletin 304 of February, 1928, pages 766 to 850 inclusive. It is a summary of progress to date (October 16, 1928), and, like the preceding report, presented without comment or discussion.

Hearings were resumed in Washington, November 9, 1927, before Commissioner Joseph B. Eastman, and Andrew M. Bunten, Chief of the Section of Depreciation, Bureau of Accounts.

It was announced that because of their interelationship three proceedings would be held jointly, namely: Depreciation Charges of Steam Railroads, Docket No. 15100, Depreciation Charges of Telephone Companies, Docket No. 14700, and General Revision of Accounting Rules for Steam Railroads, designated as Ex parte No. 91.

The first witness was John W. Roberts, a Consulting Accountant of Chicago, who presented a plan for depreciation accounting having the support of the National Industrial Traffic League and the National Council of Traveling Salesmen's Association. Mr. Roberts in presenting the so-called "Alternative Plan" explained its construction, and stated that it was designed specifically to serve the following purposes:

> (1) To state the periodic financial status.
>
> (2) To classify expenditures and receipts according to their character, in so far as that is compatible with classification according to their productive purpose.
>
> (3) To classify expenditures and receipts according to their productive purpose, the quality of congruity being a determinative consideration in the classifications referred to in this and the preceding item.
>
> (4) To protect the invested capital by disclosure of accounting facts which relate to its exhaustion and subsequent restoration, and by making proper distinctions between expense and capital charges.
>
> (5) To promote efficiency and economy in operation and maintenance by disclosing performance costs which are inclusive of all elements of attached expense, which will permit of true comparisons of the cost of unit operations.
>
> (6) To differentiate between public service, the cost thereof and the compensations received therefor, and private enterprise, its costs, and compensations.
>
> (7) To properly respect as accountable entities, and record all transactions which affect those obligations to the general public referred to heretofore as the seventh requirement of a modern railway accounting system.

Following is the arrangement of the general accounts in the operating expense classification:

Name and Order of Arrangement

	Alternative Plan		*Present Plan*
I	Maintenance of Way and Structures—Rail Line	I	Maintenance of Way and Structures
II	Maintenance of Equipment—Rail Line	II	Maintenance of Equipment
III	Conducting Transportation—Rail Line	III	Transportation—Rail Line
IV	Traffic—Rail Line	IV	Transportation—Water Line
V	Transportation for Company Service—Credit RL	V	Miscellaneous Operations
VI	Incidental Operations — Rail Line	VI	Traffic
VII	Water Line Operations	VII	General Expenses
VIII	Motor Line Operations	VIII	Transportation for Investment—Credit
IX	General Overhead Expenses		

The general accounts in the "Alternative Plan" are divided between Line-Haul, Station and Train-Terminal charges and subdivided into primary and sub-primary accounts, totaling 1098 in number as compared with the present classification of 197 primary accounts.

The presentation of the Roberts plan occupied three days, with the exception of a brief period when Fred A. Barnes, Assistant Director of the I. C. C. Bureau of Accounts, presented the Bureau's latest revision of accounting rules (which was published in April, 1927, by the Railway Accounting Officers' Association in their Bulletin No. 113, and included in your Committee's report for last year, printed in Bulletin No. 304, beginning with page 820). The Roberts plan and testimony relating thereto has been printed by the Presidents' Conference Committee (711 Commercial Trust Building, Philadelphia, Pennsylvania).

March 23, 1928: At the invitation of the Commission, J. E. Slater, Secretary and Treasurer of the American Brown Boveri Electric Corporation, testified and analyzed the "Alternative Plan" presented by Mr. Roberts. He expressed the opinion that the plan would provide little, if any, information of use for operating or administrative purposes not provided for by the present plan, and that the arbitrary basis of apportionments is not sufficiently accurate to make the results useful for checking purposes.

Hearings were resumed June 14, 1928, and continued to June 22, 1928. After cross-examination of previous witnesses, testimony on behalf of the railroads as to principles and conditions which should govern any revision of accounting was presented by F. J. Fell, Jr., J. J. Ekin, W. E. Eppler, E. M. Thomas, H. W. Johnson and F. W. Sweney.

Other witnesses testifying were John H. Williams and L. R. Bitney.

Notice has been issued that these hearings will be resumed in Washington, October 22, 1928.

Appendix D

(4) STUDY AND REPORT PROGRESSIVELY UPON METHODS AND FORMS FOR GATHERING THE NECESSARY DATA FOR KEEPING UP TO DATE THE PHYSICAL AND VALUATION RECORDS OF THE PROPERTY OF RAILROADS WITH RESPECT TO:

(a) Changes made necessary in government regulations.
(b) Simplicity and practicability of use.

B. A. Bertenshaw, Chairman, Sub-Committee; E. Y. Allen, A. M. Blanchard, R. R. L. Bullard, Alfred Holmead, W. R. Kettenring, W. T. Mead, J. T. Powers, James Stephenson, J. W. Webster, A. P. Weymouth, Louis Wolf.

(a) CHANGES MADE NECESSARY IN GOVERNMENT REGULATIONS

History

Effective as of July 1, 1914, the Interstate Commerce Commission issued Valuation Order No. 3, "Regulations to Govern the Recording and Reporting of all Extensions and Improvements or Other Changes in Physical Property of Every Common Carrier." The intent of the Order as stated therein was to prescribe a uniform method for recording and reporting the investment in changes to the physical property of the railroads. The requirements in this Order were very meager in that there were no provisions for recording or reporting changes in quantities or units, the detail cost only of the various changes being required.

Effective July 1, 1917, the Commission issued Valuation Order No. 3, "First Revised Issue." This Order superseded the original issue of 1914 and prescribed an elaborate and rather burdensome system of records including a detailed list of units for reporting quantities added and retired. The Order further required in addition to the gross cost of the project the unit cost of each unit affected. This Order did not require quantities retired to be in terms of the basic valuation but prescribed that they should be reported in terms of the units listed in the Order. This would seem to make it apparent that it was either the intent of the Commission to itself reconcile any differences between the units listed in the Order and those in the basic valuation or that this feature was overlooked.

Under date of February 1, 1918, the Director of Valuation issued a notice to the effect that until further notice, returns to Valuation Order No. 3 were suspended. The railroads, however, were to keep their accounts in all respects as required by the Order so that at any future time the returns called for under the Order could be made up and transmitted to the Commission.

The Commission made effective January 1, 1919, Valuation Order No. 3, "Second Revised Issue." This Order superseded and canceled the "First Revised Issue." This Order prescribed a series of records and forms to be compiled by the railroads retroactive to their valuation dates.

Included in the forms prescribed was the Record of Property Changes which was to be made in accordance with "Exhibit E" and was not subject to change or modification by the railroads. This Order does not require the cost per unit as was the case with the previous one, but requires the aggregate cost unless the work was done at a contract price per unit, said aggregate cost to be distributed between labor, material, contract payments, etc. It is necessary under this Order, however, to give an accurate list of the units and quantities involved in each change. The terms in which these quantities added or retired are to be stated, is prescribed as that of "so far as possible in terms of the inventory taken by the Commission."

The Commission made effective February 1, 1920, Supplement No. 1 to Valuation Order No. 3, Second Revised Issue. This Supplement for the first time prescribed a certain system of reports and records for changes in "non-carrier" property as separate from "carrier property," the provisions being retroactive to the date of valuation.

On September 27, 1920, the Commission issued Supplement No. 2 to Valuation Order No. 3, Second Revised Issue, which extended the time allowed for filing B.V. Forms 586 and 587 from 30 days to 60 days after the close of each six months' period and B.V. Form 589 from 60 days to 90 days after December 31st, of each calendar year.

On February 12, 1923, the Commission issued Supplement No. 3 to Valuation Order No. 3, Second Revised Issue, which modified the Order to the extent of allowing the railroads to vary the order and arrangement of data required, including the Record of Property Changes to suit the convenience of the railroads, provided the minimum information required by the Order be shown.

Effective January 1, 1928, Supplement No. 4 to Valuation No. 3 was issued.

On June 12, 1928, the Commission approved "Outline of Plan for Bringing Land Valuations to December 31, 1927, and Such Other Date or Dates as May Be Fixed by the Director of Valuation."

Effective May 15, 1928, Valuation Order No. 24 was issued.

Effective July 1, 1928, Valuation Order No. 25 was issued.

These last five Supplements and Orders will be dealt with in detail later.

General

In the Committee's report last year were included the following subjects:

(5) Mandatory Forms Required by Federal Regulations.
(6) List of Units of Railway Property.

These two subjects are fundamental to all methods and forms designed for gathering data for keeping up to date the physical and valuation records of the railroads.

Since the Committee made its report on the above subjects, the Interstate Commerce Commission has as outlined above issued:

(1) Supplement No. 4 to Valuation Order No. 3, Second Revised Issue.
(2) Supplement No. 5 to Valuation Order No. 3, Second Revised Issue.
(3) Outline of Plan for Bringing Land Valuations to December 31, 1927, and such other Date or Dates as may be fixed by the Director of Valuation.
(4) Valuation Order No. 24.
(5) Valuation Order No. 25.

These Orders and Supplemental Orders affect very materially portions of the report made by the Committee last year. In its report this year, therefore, the Committee is offering forms and subject matter different from that presented in its last report, to be considered as supplemental thereto until such time as methods and conditions have become stabilized to the extent that a comprehensive report may be presented for inclusion in the Manual.

(1) SUPPLEMENT NO. 4 TO VALUATION ORDER NO. 3, SECOND REVISED ISSUE

Supplement No. 4 to Valuation Order No. 3, Second Revised Issue, is a comprehensive list of units prescribed for use by the railroads in preparing completion reports and other valuation records.

In 1921 the Presidents' Conference Committee in collaboration with the Bureau of Valuation designated a List of Units to be used in connection with Valuation Order No. 3, Second Revised Issue. This List of Units was similar to the Units used by the Bureau of Valuation in their inventory and was intended for use in maintaining and perpetuating the Valuation Inventory. The railroads in general have used this List of Units in complying with the requirements of Valuation Order No. 3.

Supplement No. 4 makes mandatory the use of the units prescribed in the list and any variations therefrom may be made only when modifications are necessary to harmonize the report of changes with the original or basic inventory of a particular carrier. There is a permissive clause, however, which allows of additional descriptive information when this is believed to have a material bearing on the cost of the unit.

The Committee after giving consideration to the units ordinarily used in reporting and recording railway construction, the units used in the original or basic valuation inventory, the units as listed by the Presidents' Conference Committee in 1921 and to the units prescribed in Supplement No. 4, has concluded that the latter "List of Units" is in most cases amply sufficient for all practical purposes, and in many instances contains much more detail and description than has heretofore been used. In case any railroad finds physical units in its property not included in Supplement No. 4 or finds it necessary to add descriptive information, it may do so in compliance with the Order.

(2) SUPPLEMENT NO. 5 TO VALUATION ORDER NO. 3, SECOND REVISED ISSUE

This Supplement to Valuation Order No. 3, effective July 1, 1928, consists of instructions for compiling and filing B.V. Form 588. The ordering paragraph provides that each Carrier subject to the Interstate Commerce Act "be required within 90 days from the date prescribed by the Director, Bureau of Valuation, to file with the Commission on B.V. Forms Nos. 588 a statement of the property added since the inventory or since the date of any such previous list, and its cost, and a statement of the property retired or released since the inventory or since the date of any such previous list, and its cost, to December 31, 1927, or to such other date or dates as may be indicated, in accordance with the list of property units attached to Supplement No. 4, Valuation Order No. 3, Second Revised Issue and the detailed instructions relating to the preparation of Forms Nos. 588."

Vauation Order No. 3, Second Revised Issue, provided for only one Form 588, while Supplement No. 5 prescribes several forms as follows:

(a) B.V. Form No. 588—R, for reporting all property changes.
(b) B.V. Form No. 588—Subschedule L, for showing detailed information for changes in land owned or used for common carrier purposes.
(c) B.V. Form No. 588—Subschedule X, for reporting detailed descripton and costs of changes in machinery and apparatus.
(d) B.V. Form No. 588—Subschedule A, for reporting the detailed cost of equipment.
(e) B.V. Form No. 588—Subschedule C, for reporting detailed description of equipment—Account 51—Steam Locomotives.
(f) B.V. Form No. 588—Subschedule E, for reporting detailed description of equipment—Account 53—Freight Train Cars.
(g) B.V. Form No. 588—Subschedule F, for reporting detailed description of equipment—Account 54—Passenger Train Cars.
(h) B.V. Form No. 588—Subschedule H, for reporting detailed description of equipment—Account 56—Floating Equipment and Account 57—Work Equipment.
(i) B.V. Form No. 588—Subschedule J, for reporting detailed description of equipment—Account 58—Miscellaneous Equipment.
(j) B.V. Form No. 588—Subschedule B, for showing summary by reporting periods of units and costs due to Changes in Equipment.
(k) B.V. Form No. 588—Subschedule B-1, for reporting detail of changes in equipment summarized to furnish certain information required by Subschedule B.
(l) B. V. Form No. 588—Subschedule M, for reporting changes in physical property owned and "held for purposes other than those of a common carrier."

All of these forms are 11 by 17 inches in size and the information required is indicated by captions in the column headings or by similar indications preceding blank lines to be filled out.

While Supplement No. 4 to Valuation Order No. 3, Second Revised Issue, which is the List of Units prescribed for use in the preparation of Completion Reports and the Record of Property Changes, is made effective as of Jan. 1, 1928, Supplement No. 5 to Valuation Order No. 3 provides that the statements (on B.V. Forms 588) of property added or retired shall be "in accordance with the list of property units attached to Supplement No. 4, Valuation Order No. 3, Second Revised Issue." This therefore makes the new List of Units retroactive, at least on B.V. 588 Forms, to the date of valuation or to the date to which B.V. Forms 588 had been previously compiled, thereby requiring the railroads to incorporate on the new B.V. 588 Forms new features and information not called for in the 1921 List of Units (mentioned in connection with Supplement No. 4) and therefore not included in their Valuation Order No. 3 Records.

The "Record of Property Changes" designated as Exhibit "E" in Valuation Order No. 3, Second Revised Issue, was intended to record and consolidate periodically units of like kind with their cost, that had been added or deducted from the railroad property. It is clearly evident that the "Record of Property Changes" is of great importance, since it furnishes the prinpical intermediate or summarizing step between the completion reports and B.V. 588 forms. The Committee in its report last year included forms upon which this information was to be collected, but the information to be supplied on the schedules and subschedules in Supplement No. 5 makes necessary the design of new forms.

The Committee in its study of Supplement No. 5 has given careful consideration to the various requirements in the Order and to the design of forms that will collect and record the data in such shape as to not only be used in compiling B.V. 588 forms, but may also be used in collecting data for the Depreciation Order, Interstate Commerce Commission Docket No. 15100 and also for use in Recapture Proceedings.

Supplement No. 5 provides that property added shall be reported, together with its cost, separately from property retired and shall be in terms of the units shown in Supplement No. 4. Where property that was included in the final valuation of the railroad has been retired the quantities reported for such retirement must agree with the quantities in the final engineering report, including any adjustments that may have been made in conferences or hearings. Retirements of property installed since the date of valuation and included in Valuation Order No. 3 records and reports should show quantities that agree with the record of installation of the property.

"Retirements shall be subdivided to show separately—

(a) Property included in the basic valuation reports and subsequently retired.

(b) Property not included in the basic valuation reports, but installed since date of inventory and so reported through the records and reports prescribed by Valuation Order No. 3."

"The costs to be reported applicable to property retired other than land shall be—

(a) "For property included in the basic valuation reports, the aggregate cost for construction and improvement applicable to the particular units of property retired. If such cost is not ascertainable, or if the carrier has recorded retirements in its record of property changes on the basis of the basic valuation reports, the carrier shall report the cost of reproduction new in accordance with the basic valuation report.

(b) "For property not included in the basic valuation reports but installed since date of basic valuation and included in the records and reports prescribed in Valuation Order No. 3, the cost included in such records and reports covering the construction and the improvements of such property.

"In any case an explanation of the basis on which the retirements have been stated shall be made.

"With respect to costs to be reported for retirements, in connection with betterments applied, the above requirements may be limited to consequential items, such as those under primary accounts, 6, Bridges, trestles, and culverts; 9, Rails; 10, Other track material; 11, Ballast; and to substantial items, under equipment and other accounts.

"For land that has been retired the Supplement provides: the costs to be reported under the heading 'Property Retired' for items of land shall be, the cost at the date of dedication to public use, and separately, the amount entered in the investment account to record therein the retirements."

The above requirements with respect to property retired are among the outstanding features of the Order. In the past it was not required that the property retired be distinguished as between that which was included in the basic valuation and that which had been added subsequent to valuation date, so that at this time it will be a difficult matter for the railroads to so identify or classify property retired, especially as regards items included in the so-called "mass property."

The railroads in the past have generally retired property at ledger value or estimated ledger value and in the case of betterments, retirements were made at current prices, all in accordance with the Classification of Accounts. The above requirements necessitate a restatement of retirement values used in accounting. This restatement of retirement values to those of the final valuation is identical with one of the requirements of Depreciation Order No. 15100. These features of the Order will prove particularly burdensome to those railroads which have, subsequent to their date of valuation, made extensive changes and improvements in their property.

On the date of the receipt of the Order to comply with the requirements of Supplement No. 5 to Valuation Order No. 3 a large number of railroads had not received their "Final Valuations." Such railroads will be at a decided disadvantage in complying with the above requirements for the reason that the "Final Valuation" may make material changes in various quantities and their costs. These railroads will undoubtedly be faced with the necessity of revising at some future time, at additional effort and expense, the returns as made up in compliance with the Supplement.

Supplement No. 5 provides that "all changes of property that is jointly owned or jointly constructed must be shown separately from the other property." The total cost of such property is to be shown in the description column, together with the names of the owning or participating parties with the amounts owned or paid by each party, while only that portion of the cost paid by the reporting railroad will be handled under the appropriate heading of "property added" or "property retired."

Section 17 of the Supplement provides that "if there have been other changes which a carrier considers affect the condition and value of its property, such changes when reported shall be stated separately, with their costs, from those the cost of which affects the investment in road and equipment account, but in conformity with the general rules herein given and an explanation made of the accounting performed in connection with such changes. Changes coming within this category shall be subdivided by yearly periods." This provision would seem to include renewals and replacements in kind and changes charged to operating expenses.

Section 18 of the Supplement permits railroads to use subschedules other than those prescribed in the Order for reporting other details provided they are first approved by the Bureau of Valuation as to form and method of preparation.

Section 19 of the Supplement separates the property in the road accounts into two classes, "mass property" and "structural property." "By 'mass property' is meant property of like kind and characteristics, the quantities of which may be considered collectively and reported as a single item. By 'structural property' is meant property which from its nature must be individualized and reported separately from property of like kind and characteristics."

Section 22 of the Supplement provides that "'mass property' shall be listed in total by units for all years to cover the complete period subsequent to valuation date or since the date of any such previous list, unless specific instructions to the contrary are given, and the weighted average date (year) of installation shall be shown for each item except for clearing, grubbing, grading or items in Account 12. In addition to the above (if the carrier so elects), 'mass property' may be segregated by years or portions thereof."

Changes in "Structural Property" such as a bridge, building, machine, plant or facilities referred to as "Structural Property" shall be reported separately from every other such item of "Structural Property." These changes must be reported so as to show date of installation of the new facility, date of additions and betterments and date of retirements of entire facilities or parts of facilities. In reporting retirements of units in "Structural Property" and also machinery and apparatus upon which additions and betterments have been made subsequent to date of valuation, net costs of any such additions and betterments shall be recorded separately from the costs reported for the unit as of valuation date or as installed subsequent to valuation date.

For recording and collecting data in connection with changes in "Structural Property" the Committee submits forms Exhibit "A" and Exhibit "B," the latter being a continuation sheet of the former. These forms are 11 by 17 inches in size and a separate sheet or sheets used for each structure, but only those structures in which changes have occurred subsequent to valuation date should be recorded thereon.

Provision has been made in this form for recording the quantities, unit prices and amount allowed in the Engineering Report, for all pricing units in the structure. A brief description of the change is to be shown in the three lines provided in the heading of the columns, and in column 1 only pricing units and sufficient description thereof will be shown. Opposite "Addition or Retirements" and in column headings will be indicated in case of retirements whether they were made in connection with betterments, were included in Engineering Report or whether installed subsequent to valuation date as "Bett. Retirement," "Retirement E. R." or "Retirement V. O. 3."

In case retirements of property included in the basic valuation have not been made on the basis of cost of reproduction new in said basic valuation it becomes necessary to restate the retirements to such basis and this form supplies the information necessary for the restatement.

Forms Exhibit "C" and Exhibit "D" are to be used for recording changes in "mass property," Exhibit "D" being a continuation sheet, both forms 11 by 17 inches in size. Each unit in which there has been a change since valuation date is to be listed in the blanks at the tops of the columns. In column 7 is a brief description of the change and the first entry on this sheet should be "Property included in Engineering Report." In column 8 is to be recorded the date of installation of property retired in order to distinguish between that included in the Engineering Report and that installed since valuation date. That included in Engineering Report may be indicated in this column by "E.R."

This form permits of a summation as of any year or period for all like units, and as in the case of "Structural Property" for restating of retirements the information is in convenient form for segregating such units and applying Engineering Report unit prices.

On each of the above forms is a column headed "Amount" adjacent to the column headed "Quantity." Attention is called to the fact that the Order does not require the cost to be shown for each unit. For "Structural Property" only the total cost of each structure or facility need be shown and for "Mass Property" the total cost for each mass account may be shown.

Subschedules C, E, F, H, and J, prescribed in the Supplement, are for reporting detailed description of new, converted or rebuilt equipment. The information called for on these forms for new equipment will usually be found in the specifications for purchase.

Subschedule "B-1" records the detail of changes in equipment summarized so as to furnish a portion of the information required on subschedule "B." On this subschedule "B-1" must be shown the description of additions and betterments, date of application, the charges for property added, credits for property retired and net charge or credit to the various units of equipment for the period reported. In addition, this form requires for units of equipment retired, a description of the additions and betterments previously reported for these units with the date of application of the additions and betterments and the net costs.

For recording changes in equipment the Committee submits Exhibit "E" 11 by 17 inches in size. Space has been provided at the top of this form for describing the various kinds or classes of equipment; only those spaces will be filled out as are applicable to the particular class of equipment under consideration.

As additions and betterments are made to the particular units of equipment the information is recorded in the several columns on the form. At the head of each column is left a space for describing the additions and betterments such as "metal truck bolsters" "slotted coupler yokes," "electric head light" or "superheater."

There are two methods of assembling the information on this form. The first is to list each unit of equipment in numerical order under column 1 "Unit number." In some instances, particularly for freight train cars, this would require a large number of sheets upon which there would be very few and perhaps no entries on some of the sheets for a number of years. The second method is to list under column 1 "Unit Number" the particular unit as changes are made, in date order. This method would provide for a very condensed form and for quite a number of years after the purchase of new equipment would present little difficulty in identifying all changes to any particular unit. However, after the equipment group has reached the age when additions and betterments are rather generally being made there would be difficulty in finding out on any particular unit whether or not additions and betterments had previously been made to that unit and there would possibly be a duplication of entries for a particular unit which would in part defeat the purpose of this form, which is the record of additions and betterments in convenient form on any particular unit up to the time of its retirement.

Exhibit "F" 11 by 17 inches in size is a form designed for collecting by accounts the amounts to be transcribed to B.V. Form 589—"Annual statement of charges and credits to the investment account for property brought into or retired from operation." Exhibit "G," 11 by 15.4 inches, in size is a continuation sheet for Exhibit "F." It is to be used as a "rider" sheet, printed on both sides; the reverse side being the same as the one shown except that the binding margin and line numbers will appear on the right of the sheet instead of the left.

While these latter two forms are not directly a part of Supplement No. 5 to Valuation Order No. 3, the Committee believes that because Valuation Order No. 3 provides that B.V. Form 589 shall be compiled from the "Record of Property Changes" they should be included with the other forms in this group. Entries on this form are to be made directly from the "Completion Reports" for each account number affected by any particular A.F.E. The total debit or credit for each A.F.E. is shown at the left of the form and in each double vertical column will be indicated the account number with its corresponding debit and credit.

This form allows for a vertical addition of debits and credits to each particular account and therefore provides the information to be transcribed to the B.V. Form 589. An alternative form is in use by some roads on which the account numbers are listed at the left of the sheet and the A.F.E. numbers shown in the double vertical columns across the sheet. The Committee recommends this form because in most cases there will be fewer account numbers involved than A.F.E. numbers and therefore fewer number of sheets for each reporting period.

The Committee wishes to have it clearly understood that these forms are presented at this time as information only and are intended as a guide to the methods to be followed and the principles involved in compiling the information required by the Supplement. Lack of time since the Supplement was issued has not afforded the opportunity for a thorough practical test and the problems involved will vary on different railroads due to their mileage and the volume of reports to be handled and also due to differences in organization and methods of handling Valuation and Accounting matters in the past.

(3) OUTLINE OF PLAN FOR BRINGING LAND VALUATIONS TO DECEMBER 31, 1927, AND SUCH OTHER DATE OR DATES AS MAY BE FIXED BY THE DIRECTOR OF VALUATION.

This plan sets out that there are parts of properties which are of relatively small importance compared with total value of the lands used by the railroads, and that there are also properties or parts of property in which there has been no substantial change in value since the original value was placed on these properties. Railroads are accordingly asked to indicate those parts of their properties in which there has been no substantial change in value and therefore complete reappraisals not justified.

After the railroads have complied with this requirement and necessary investigations have been made and it is found that railroads' suggestions are reasonable, written agreements will be arranged for between the railroads and the Land Section. Where there have been no significant changes in the ownership or use of railroad property, prints of valuation maps prepared in connection with primary valuation work may be used in bringing land valuations to date. Where there have been changes it is of course necessary to have maps showing the necessary information in regard to such changes made since the date of valuation.

Where carriers are appraised they shall prepare in duplicate lists of all sales within designated limits applicable to lands in which it is thought there have been substantial changes in value. They are to furnish copies of these lists to the Land Section of the Bureau of Valuation, who will make checks of the information furnished for the purpose of determining its completeness and accuracy.

Where railroads furnish information indicated above to the Land Section of the Bureau of Valuation, representatives of the railroad and the Land Section are to participate in the verification of the data furnished and agree upon the record data, although not necessarily upon the applicability of the data to the properties being appraised. The application of the data and the fixing of unit values to the property appraised are to be done independently by the railroads and the Land Section.

Representatives of the Carriers and the Land Section are to participate in the establishment of tentative zone limits. It is thought that the zone limits of the original appraisals may be adopted and any changes in value or utility affecting parts of the original zones may be taken care of by creating subzones. Questions arising as to area, classification, or use will be disposed of through conferences.

One of the interesting features in this plan is in connection with leased property and reads as follows: "Some modification of the requirements of Order No. 15 may be necessary in order to classify lands leased to private parties in accordance with recent instructions within the Bureau. Consideration should, however, be given to pending proposals as to the revision of the Commission's accounting requirements in accordance with which rents received by carriers for incidental private or semi-private use of their property will be classified as operating revenues, presumably with approval of a carrier classification for many items of property now set up as non-carrier. Such a change in the prescribed accounting procedure would apparently affect the whole basis of the instructions now regarded as governing and would, in great measure at least, obviate the need of returns to Order No. 15."

(4) VALUATION ORDER NO. 24

The Interstate Commerce Commission issued, effective May 15, 1928, Valuation Order No. 24, "Regulations and Instructions relating to the recording and reporting changes in physical property of every common carrier subject to the provisions of the act to regulate commerce whenever such changes occur in connection with construction, transfer, lease or abandonment of property."

This order provides that any railroad upon being granted authority on or after the effective date of this Order to construct a new road, a branch line or an extension to an existing line shall, within 90 days after commencement of common carrier operations, comply with the provisions of section 8 to Valuation Order No. 3 as revised. This section provides that maps, profiles, plans, diagrams or other data for newly built roads as will show the nature and extent of the property and its location shall be filed with the Commission.

Valuation Order No. 24 further provides that the railroads shall file under oath with the Commission on B.V. Form No. 588 a complete and accurate inventory of the property, which inventory shall show all of the units and quantities comprising the property classified in the same manner as was done in the Valuation inventory.

The Order further provides that where one railroad is granted authority on or after the effective date of the Order to acquire property from another railroad either by purchase, exchange, merger, consolidation, lease or otherwise, which had been previously inventoried by the Commission, the railroad acquiring the property shall within 90 days after commencement of common carrier operations of the property comply with the provisions of sections 10 and 11 of Valuation Order No. 3 and Supplement No. 1 thereto.

Section 10 of Valuation Order No. 3, Second Revised Issue, provides in case of a transfer of property as indicated above, the vendor shall issue an Authority for Expenditures and make a completion report recording the release of the property while the vendee is required to issue an Authority for Expenditures and make a completion report recording the acquisition of the same property. Further instructions are given in this section for recording details of the transaction. Section 11, Valuation Order No. 3 provides for a method of handling the differences between the construction cost of the property transferred and the purchase price.

Supplement No. 1 requires the Carriers to file information called for on B.V. Forms 592, 593 and 594. Form 592 is to be filed annually, showing the physical property owned and "held for purposes other than those of common carrier." On B.V. Forms 593 and 594 "shall be listed annually, property owned and 'held for purposes other than those of a common carrier,' which consists of their dealings in and holdings of the stocks and bonds and other securities of other companies, and of the investment advances that have been made to other companies or individuals."

Valuation Order No. 24 further provides that where one railroad acquires from another railroad or other sources, property which the Commission has not previously inventoried, the railroad acquiring such property shall within 90 days after commencement of common carrier operations of the property, file with the Commission on B.V. Form 588 a complete and accurate inventory of the property including all units and quantities classified in a manner similar to that in Valuation Inventory.

In each of the three cases mentioned above, that is, either the construction of a new road, the acquirement of property, which had been previously inventoried by the Commission or the acquirement of property which had not been inventoried by the Commission, the railroad is, after the date of the inventory mentioned, required to comply with the provisions of Valuation Order No. 3 Revised.

The Order further requires that where a railroad is granted authority on or after the effective date of the Order to abandon either a part or an entire line, shall within 90 days after the date of the abandonment of the property, file with the Commission a statement setting forth all the facts relative to the abandonment, indicating the disposition made of the abandoned property showing location and limits of the property abandoned and where said abandoned property is less than a valuation section, file on B.V. Form 588 a complete and accurate inventory showing all units and quantities comprising the property abandoned.

(5) VALUATION ORDER NO. 25

Under date of June 12, 1928, the Interstate Commerce Commission issued its Valuation Order No. 25, distribution of which commenced in September. This Order in general calls for an extension to "a new valuation date or dates" of the information called for under the section headings in the original basic Accounting Reports. Under this Order, however, all of the work is to be done by the Carriers, the supporting data to be complete and so referenced that "the accountant of the Commission can examine this record without further search upon his part."

The reports must be uniformly prepared upon sheets 8 by 12½ inches in size, one copy apparently being all that is required by the Commission. There need be prepared only as many more copies as may be required by the Carrier itself. To provide for possible future demands, a carbon-backed copy should be made permitting such subsequent reproduction by blue or white print method as may become necessary.

In this Valuation Order it is required that the report be filed "within 90 days from the date prescribed by the Director of the Bureau of Valuation." This is the same time limit as is imposed in Supplement No. 5 to Valuation Order No. 3 for the filing of B.V. Forms 588. Since a great deal of the data in the revisions under this Order is contingent upon the completion of returns on B.V. Forms 589, it is obvious that returns under this Order can not be made until after the completion of work on B.V. Forms 588.

The original basic Accounting Reports were made up of a series of chapters (preceded by an "Introductory" section) in the following order:

Corporate History.
Development of Fixed Physical Property.
History of Corporate Financing.
Results of Corporate Operations.
Investment in Road and Equipment.
Original Cost to Date.
Improvements on Leased Railway Property.
Miscellaneous Physical Property.
Investments in Other Companies.
Aids, Gifts, Grants and Donations.
Materials and Supplies.
Leased Railway Property.
General Balance Sheet Statement.
Detail of Individual Issues of Funded Debt.

The chapter designations in Order No. 25 are the same as those in the basic Accounting Report, except that there is omitted the chapters on "Original Cost to Date," "Investments in Other Companies," "Materials and Supplies," and "Details of Individual Issues of Funded Debt."

For the first four of these chapters, "Corporate History," "Development of Fixed Physical Property," "History of Corporate Financing," and "Results of Corporate Operations" information for the "post valuation date" period is to be reported essentially as it was reported in the basic Accounting Report. The instructions in the Order are illustrated with sample forms, and there do not appear to be any radical differences from the arrangement with which we have become familiar in the basic reports.

Accountants of the Bureau of Valuation found it advisable from their experience to gather the necessary data for these sections on "schedules" or working sheets before proceeding to write up the data in final form. That method is recommended in this post valuation accounting work, in order that the returns made under this Order may readily be reviewed and verified by representatives of the Commission.

The returns called for in the chapter on "Investment in Road and Equipment Account" are essentially a classified summary of the increases in this account from date of basic valuation to the new valuation date and a summary reconciliation statement showing the classified differences between this increase and the returns made under Valuation Order No. 3 for the same period.

The Order furnishes sample forms for both summaries. The first sample form or "schedule" calls for the balances in the account on basic valuation date and on the new valuation date, and for a classification of the difference between those figures as to the amounts involved in "Cost of road and equipment acquired through purchase, merger, consolidation, or reorganization," "cost of new lines and extensions," "cost of additions and betterments" and the "net adjustments during the reporting period, which are not applicable to additions or retirements of property made during the period." These amounts, other than the last "adjustment" figure, are to be further subdivided as to classification of consideration essentially as was done in the basic valuation report. This classification is clear, but it may be pointed out that the introductory "General" section of the Order permits Carriers to consider and report "pay rolls," "audited vouchers," and "materials and supplies" as "recorded money outlay." Such handling will greatly simplify the work. It is further to be noted that expenditures from advances by a parent company appearing in the account of Investment in Road and Equipment of a subsidiary may be designated in the returns in this chapter for such subsidiary as "non-negotiable debt to affiliated companies" without further sub-classification of the outlay.

It is the intent that the classified report of expenditures for construction of new lines and extensions and for additions and betterments shall contain all charges booked during the period, whether or not reported in returns under Valuation Order No. 3. Such charges in this post valuation period will contain, without segregation, "delayed accounting" charges following the basic valuation date for items included in the inventory as well as "advance charges" for items not completed before the end of the period and not to be reported under Valuation Order No. 3 for the period.

The balancing item designated as "net adjustments during the reporting period, which are not applicable to additions or retirements of property made during the period," will ordinarily have a very limited use and embrace only adjustments of charges antedating the basic valuation date in connection with matters such as long deferred adjustment or allocation of organization expenses, etc., special in nature. This balancing adjustment item is not a summarization of the differences developed in the reconciliation statements.

The sample form given for reporting the summary reconciliation between amounts reported on B.V. Forms 588 and 589 for the period involved and the increases in Account 701 for that period, has two principal divisions:

> First. Amount in Account 701 for the period and not reported on B.V. Forms 588 and 589.
> Second. Amount on B.V. Forms 588 and 589 for the period not in Account 701.

The charges in the first division are further to be set up by "charges" and "credits," the "charges" being made up of those applicable to items (1) included in basic valuation reports, (2) not turned over to operation before the end of the period reported, and (3) not reported on B.V. Forms 588 and 589 for other reasons. The "credits" are also to be further reported as made up of those applicable to items (1) retired prior to basic valuation date and not in the basic reports, (2) those not reported on B.V. Forms 588 and 589 for other reasons, and (3) excess of credits in accounts over credits on Forms 588 and 589 in connection with retirements of property.

The "charges" in B.V. Forms 588 and 589 and not in Account 701 are to be divided as between those applicable to (1) property placed in service in the period, but recorded in the accounts before or after the period, or (2) not recorded in the accounts for other reasons.

The "credits" are also to be divided as between those applicable to (1) property retired during period, but recorded in accounts before or after the period, or (2) not recorded in the accounts for other reasons, and (3) the excess of retirement credits on B.V. Forms 588 and 589 over the amounts recorded in the accounts.

All of the differences between the accounts and B.V. Forms 588 and 589 on these reconciliation statements, when they are for "other reasons," must be fully described in the supporting papers.

It is obvious that in the classfication of outlay and in this reconciliation between the accounts and returns under Valuation Order No. 3, lie the major part of the work under Order No. 25. This reconciliation was not called for under Valuation Order No. 3, and very few Carriers have attempted any such reconciliation.

In that general situation, two things are clearly essential: 1st, the gathering of the data necessary for this return, and 2nd, the installing of a well-defined system of carrying on reconciliation work currently. The question then arises as to whether the current method to be devised shall be extended back to all projects since valuation date, or whether the gathering of data for returns under this Order may best be done separately by some more expeditious method. The methods selected will depend, in a large degree, upon the organization and system of each Carrier. The various factors and suggested methods may be discussed, from which the system best adapted to individual conditions may be selected.

The sum totals of the differences between the books and the returns under Valuation Order No. 3 are developed from the differences appearing when comparison is made between the books and the Valuation Order No. 3 returns for individual projects. The tabulation and comparison by individual projects is essential and may be made either on cards for each project or in tabulations wherein a line is assigned to each project. Under either method it seems clear that on each card or upon each line provision should be made for collecting, in appropriate columns, all the information needed for the return under this Order. This would include, beside the A.F.E. designations and references, (1) the charges or credits on the books, by years, with a total for the project; (2) the date of completion and amount reported on B.V. Form 589; (3) the differences between totals on the books and on B.V. Form 589; (4) the posting of such difference to one or other of the reconciliation headings specified in the Order; (5) a brief description of differences if for "other reasons," and (6) a classification of the character of outlay under the designations in the Order.

The proponents of the card and tabular systems will find it difficult to reconcile their points of view as to the relative merits of the two systems. The user of card systems argues for their flexibility, that their employment permits of the work being carried on intermittently, that they may be assembled and recapitulated by 589's for any year or for any subdivision, by either 589's or by ledger divisions. The user of the tabular form points out that in the return under this Order it is the amount on the ledgers for the period that is the governing feature, that it is the extent to which the returns on B.V. Form 589 differ from such ledger totals that must be explained, that the columnar arrangement permits of gathering on each line, with supplementary or "rider" sheets, if necessary, all the data related to the amounts on the ledger for each project for the period, and that this arrangement makes recapitulation and checking by corporations, periods, or other subdivisions easier and more positive.

It is clear that with the necessary information shown on either the card or the tabular system, in any individual case, that system will work best, for which the user has a natural preference. It is also clear that the reconciling of past entries has materially different aspects from the current reconciliation that can be made a part of the routine processes involved in fulfilling the requirements of Valuation Order No. 3.

Under the chapter on "Improvements on Leased Railway Property," information is to be given identical in character and arrangement with that in the chapter on "Investment in Road and Equipment Account."

The balance of the chapters in the Order, namely, "Miscellaneous Physical Property Account," "Aids, Gifts, Grants and Donations," "Leased Railway Property," and "General Balance Sheet" are also to be prepared essentially as in the basic Accounting Report, full instructions and sample forms being given in the Order.

Although the form of the Order leaves the new valuation date to be set for each Carrier by special instructions of the Commission, it is understood that it is the intention that this report be made as of December 31, 1927. It is also understood that it may be quite an extended period before a second new valuation date will be set in the future. Consideration should be given to the fact that some future date will again be set and that the information which is to be compiled for the returns under this Order should be from January 1, 1928, collected currently to facilitate the return at any future date that may be set by the Commission.

Consideration should also be given to the possible necessity of having to set up this data for some other period between date of valuation and December 31, 1927, contingent upon whether or not the Carrier may face recapture proceedings.

Exhibit "A"

NORTH AND SOUTH R.R.

Record of Property Changes

Structure	Sheet Number
State	Val. Sec.
Location	Structure Number
Operating Division	Account Number
Name	

Line No																Line No
	A.F.E. No.															
	Completion Report No															
	Description of Change		Engineering Report Page No.													
	Date Installed or Retired															
	Amount of Charge or Credit															
	Addition or Retirement															
	ITEM 1	Unit Cost 2	Unit 3	Quan 4	Amount 5	Quan 6	Amount 7	Quan 8	Amount 9	Quan 10	Amount 11	Quan 12	Amount 13	Quan 14	Amount 15	
1																1
2																2
3																3
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Exhibit "B"

NORTH AND SOUTH R.R.

Record of Property Changes.

Sheet Number

Structure — Structure Number

State — Val. Sec. — Location

Operating Division — Account Number — Name.

Line No.	A F.E. No																		Line No.
	Compl Rep't No																		
	Description of Change																		
	Date Inst'd or Ret'd																		
	Am't of Chge or Cr.																		
	Add'n or Retirement																		
	Item 1	Unit 2	Quan 3	Amount 4	Quan 5	Amount 6	Quan 7	Amount 8	Quan 9	Amount 10	Quan 11	Amount 12	Quan 13	Amount 14	Quant 15	Amount 16	Quan 17	Amount 18	
1																			1
2																			2
3																			3
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Exhibit "C"

NORTH AND SOUTH R.R.

Record of Property Changes

State ______ Val. Sec. No. ______

Account Number ______ Name ______

Sheet Number ______

Line No.	A.F.E. No 1	Completion Report No 2	Date Installed 3	Date Retired 4	Charges for Property Installed 5	Credits for Property Retired 6	General Description and Remarks 7	Date Installed for Retired Property 8	Unit Quan 9	Amount 10	Unit Quan. 11	Amount 12	Unit Quan. 13	Amount 14	Unit Quan 15	Amount 16	Line No.
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Exhibit "D"

NORTH AND SOUTH R.R.

Record of Property Changes

State ____ Val. Sec. ____

Account Number ____ Name ____

Sheet Number ____

Line No.	A.F.E. No. 1	Completion Report No. 2	Unit Quan 3	Amount 4	Unit Quan 5	Amount 6	Unit Quan 7	Amount 8	Unit Quan. 9	Amount 10	Unit Quan 11	Amount 12	Unit Quan 13	Amount 14	Unit Quan 15	Amount 16	Unit Quan 17	Amount 18	Line No.
1																			1
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Exhibit "E"

RECORD OF PROPERTY CHANGES

Body or Type ______
Underframe or Cylinders ______
Capacity or Lenght ______
Total Light Weight ______
Saturated or Superheated ______
Vestibule or Non-Vestibule ______
Kind of Trucks ______

Owner ______
Operating Co. ______
Account Nº ______ Class ______

Subclass ______
Series ______
1914 Cost of Repro. New $ ______
______ Original Cost New ______
Total Cost of Group ______

Builder ______ Date Built ______ Date in Service ______ A.F.E. Nº or ______ Eng. Rept Page Nº ______ Group Nº ______ Nº of Units ______

Unit Number	ADDITIONS AND BETTERMENTS																								Retired		Dis-position
1	A.F.E. 2	Yr. 3	Dr. 4	Cr. 5	A.F.E. 6	Yr. 7	Dr. 8	Cr. 9	A.F.E. 10	Yr. 11	Dr. 12	Cr. 13	A.F.E. 14	Yr. 15	Dr. 16	Cr. 17	A.F.E. 18	Yr. 19	Dr. 20	Cr. 21	A.F.E. 22	Yr. 23	Dr. 24	Cr. 25	Date 26	Amount 27	28

Exhibit "F"

NORTH AND SOUTH R.R.

RECORD OF PROPERTY CHANGES
GROSS CHARGES AND CREDITS BY A.F.E.'S AND ACCOUNTS
(For Use in Compiling B.V. Form 589)

State________ Val. Sec. No.________

Sheet____ ____ Year ending Dec 31, 19__

Line No.	A.F.E. No	Gross		Acct No.____		Acct No.____		Acct. No.____		Acct. No.____		Acct. No.____		Acct. No.____		Line No.
		Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit	
1																1
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Exhibit "G"

NORTH AND SOUTH RR

COLLECTION SHEET FOR FORM 589

State____ Val. Sec. No.____

Sheet___ of___ Year ending Dec. 31, 19__

Line No.	Acct No.____		Acct No.____		Acct. No.____		Acct. No.____		Acct. No.____		Acct No.____		Acct. No.____	
	Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit	Debit	Credit
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(b) SIMPLICITY AND PRACTICABILITY OF USE

Reduction in Number of Valuation Sections

Under assignment (b) the Committee made a study of the possible savings that might be effected through a reduction in the number of valuation sections now in use on the railroads and submits the following as a result of its study.

When the Bureau of Valuation, Interstate Commerce Commission, engaged upon the inventory of the physical property of the railroads, it divided the property of the road (with the co-operation and approval of the road) into valuation sections.

The length and number of these valuation sections were determined by giving consideration to:

(a) Owning Corporations.
(b) State Lines.
(c) Operating Divisions.
(d) Branch Lines and Spurs.
(e) Large Terminals.

Frequently valuation sections or sub-sections were assigned to smaller terminals, such as engine terminals, shop and repair points, junctions of operating divisions, etc.

The valuation sections having been assigned, the maps, and profiles, the field inventories, the collection of quantities, the application of unit prices to the quantities and finally the Engineering Report and Tentative Valuation were all made in accordance with such valuation sections. There were, however, some instances where the Engineering Report and Tentative Valuation showed a grouping or a combination of certain valuation sections over those originally assigned and used in making the field inventory. The length or limits of valuation sections very often became of great importance because of the effect on the computation of the cost of haul of materials entering into construction of the section.

Valuation Order No. 3, requires the railroads to report periodically on certain prescribed forms by valuation sections all property changes made subsequent to assigned valuation dates. Supplement No. 5 to Valuation Order No. 3—Second Revised Issue prescribed the manner of preparing and filing B.V. Form 588 showing by valuation sections property added and retired between valuation date and certain dates subsequent thereto as specified by the Commission. Similarly, Interstate Commerce Commission No. 15100—"Depreciation Charges of Steam Railroad Companies," provides that steam railroad companies shall make a redistribution of their road and equipment investment accounts embracing depreciable property and that property other than equipment shall be redistributed by valuation sections.

It is evident, therefore, that the number of valuation sections on a railroad assumes major importance as regards Mandatory Forms and reports to be filed with the Commission from time to time. The situation on some roads is that the present number of valuation sections might be reduced and still conform to the prescribed limitations of owning Corporations, State Lines, etc. The Bureau of Valuation has indicated that combinations of present valuation sections may be made within practical limitations to promote facility and economy, subject to its approval.

It was somewhat generally believed that a combination of valuation sections would materially reduce the work required in:

The preparation of Authorities for Expenditures.
The preparation of Engineering Data for property changes.
The preparation of Valuation Order No. 3 records and reports such as Completion Reports, Record of Property Changes, B.V. Forms 586, 587, 589, etc.
The compilation of B.V. Form 588, which is to be used for bringing valuations of all roads to a common date and also for Recapture Proceedings.
The necessary accounting incident to property changes.
The transfer of property without improvement, from one location to another.
The establishment and maintenance of a depreciation base, including the restatement of the Investment Account, as required by Interstate Commerce Commission No. 15100.
The computation of percentage rates and maintenance of records for checking the adequacy or inadequacy of such rates currently, in connection with Depreciation Accounting.

Tending to offset by varying degrees the savings enumerated above are certain disadvantages due to:

Valuation maps and profiles having been prepared on the old basis.
Field inventories, collection notes, and underlying data of valuation having been made on the original number of sections.
The Engineering Report having been prepared for a certain grouping of these sections, which might or might not be the same as contemplated in a present day combination of sections.
All Valuation Order No. 3, records and reports in the past having been prepared on the basis of the original sections.
Side track and Structures having been numbered or identified by valuation sections on the old basis.

This Committee in order to learn to what extent the number of valuation sections, as originally assigned, has proved burdensome, and also how much the burden of complying with the various requirements of the Interstate Commerce Commission might be lightened by combining and thus reducing the number of valuation sections, had the following questions sent to 51 of the larger railroads requesting that the various features which might involve advantages or disadvantages be given full consideration in formulating a reply:

(1) (a) How many valuation sections have you at present in reporting property changes under Valuation Order No. 3?

(b) To what number were these tentative valuation sections grouped by the Bureau in preparing your Engineering Report?

(c) To what number could these tentative sections be advantageously reduced, considering Valuation Order No. 3, Re-valuation, and Depreciation requirements, as they are now understood?

(2) Giving due consideration to all phases and operations involved, what approximately would be the saving expressed as a percentage.

(3) Please state whether or not you would recommend such a combination of tentative valuation sections, as indicated by 1 (c), and your views as to the advantages and disadvantages involved.

The responses from the various railroads indicate that 19 per cent in number favor a reduction in the present number of valuation sections, the number of miles represented by those favoring such a reduction being in almost the same ratio. There appears to be a good reason why so small a percentage favor reduction and that is that combinations or consolidations of valuation sections as originally assigned have been made in the past to such an extent that further reductions are not desirable, such reductions running as high as 60 per cent. The estimated saving was in all cases small, ranging from 0 to 5 per cent.

Conclusions

Section (a) is presented as a progress report.

Section (b) is presented as information and the Committee has concluded that no general recommendation for a combination or a reduction in the present number of valuation sections should be made. There are specific instances where certain combinations are logical and peculiar to a particular railroad. In such cases it becomes the subject of study and determination for the individual railroad as to whether the advantages of such consolidation will outweigh the disadvantages.

Appendix E

(5) REPORT UPON METHODS AND FORMS FOR HANDLING THE INTERSTATE COMMERCE COMMISSION'S REQUIREMENTS UNDER ORDER NO. 15100—DEPRECIATION CHARGES OF STEAM RAILROAD COMPANIES

C. C. Haire, Chairman, Sub-Committee; B. A. Bertenshaw, A. M. Blanchard, E. S. Butler, C. R. Harte, C. A. Knowles, W. R. Kettenring, Henry Lehn, J. T. Powers, C. K. Smith, H. R. Westcott, G. R. Walsh, Louis Wolf.

The Committee has made a study and analysis of the subject assigned this year, but in view of the present indefinite status of the Order has confined its activities to the following work:

(1) History.
(2) Bibliography.
(3) Requirements of the Order and probable method necessary to inaugurate and currently carry out the provisions thereof.

A number of conclusions have been arrived at in connection with the Order that the Committee believes to be of interest to carriers.

(1) HISTORY

General Statement

On November 2, 1926, the Interstate Commerce Commission announced its findings with respect to depreciable property of steam railroads and telegraph companies and in Orders effective January 1, 1928, prescribed the rules to govern the determination of depreciation charges as required by paragraph (5), Section 20, of the Interstate Commerce Act.

On May 2, 1927, the Interstate Commerce Commission postponed the effective date of the orders to January 1, 1929.

On June 4, 1928, the Interstate Commerce Commission further amended the seventh ordering paragraph of the Order 15100 by eliminating therefrom all reference to the latest date upon which operating steam railroad companies shall file with the Commission, estimates of the composite percentage rates.

Chronological Development of Depreciation Accounting for Steam Railroads

1907—In the Third Revised Issue—Classification of Operating Expenses, effective July 1, 1907, the Interstate Commerce Commission prescribed six primary accounts for recording depreciation of equipment. The requirements of the Third Revised Issue—Classification of Operating Expenses—were mandatory upon the carriers.

1914—Under the Classification of Operating Revenues and Operating Expenses of Steam Roads, effective July 1, 1914, the setting up of depreciation charges under eight primary equipment accounts is mandatory upon the carriers; in addition the Classification also provides thirty-seven depreciation accounts for the current depreciation of fixed improvements, although until further directed the recognition in operating expenses of current depreciation of fixed improvements is optional with the carriers.

1920—Section 20, paragraph (5), of the Interstate Commerce Act, as amended February 28, 1920, now requires that:

"The Commission shall, as soon as practicable, prescribe, for carriers subject to this Act, the classes of property for which depreciation charges may properly be included under operating expenses, and the percentages of depreciation which shall be charged with respect to each of such classes of property, classifying the carriers as it may deem proper for this purpose. The Commission may, when it deems necessary, modify the classes and percentages so prescribed. The carriers subject to this Act shall not charge to operating expenses any depreciation charges on classes of property other than those prescribed by the Commission, or charge with respect to any class of property a percentage of depreciation other than that prescribed therefor by the Commission. No such carrier shall in any case include in any form under its operating or other expenses any depreciation or other charge or expenditure included elsewhere as a depreciation charge or otherwise under its operating or other expenses."

In carrying out this provision of the Act, the Interstate Commerce Commission organized a depreciation section in its Bureau of Accounts, and instructed that section to make a preliminary investigation in the case of each class of carriers, and to report its tentative conclusions and recommendations following this preliminary investigation. Such report was to be used in each case as the basis for public hearings at which all interested parties would be given opportunity to submit evidence in support of or in opposition to the recommendations contained in the report, these hearings to be followed by the submission of briefs and oral argument, if it be desired, before Division 4 of the Commission.

In response to the Interstate Commerce Commission's invitation, the Railway Accounting Officers' Association, in conjunction with the Presidents' Conference Committee on Federal Valuation, appointed a Depreciation Committee to report to the latter. The Depreciation Committee was requested to submit its views with respect to the classes of depreciable property, average service lives and salvage values; the basis upon which depreciation charges should be accrued; and the method of determining the percentages of depreciation; also suggestions which in its judgment would be helpful to the Commission in determining the final regulations.

1921—On April 6, 1921, the Depreciation Committee submitted its report to the Presidents' Conference Committee on Federal Valuation, recommending rates for straight line depreciation charges under twenty-four accounts covering fixed improvements and eight accounts covering equipment.

1921—The Presidents' Conference Committee declined to approve this report on the theory that the property of a steam road properly maintained is not subject to depreciation, and returned it to the Depreciation Committee for further consideration.

On December 20, 1921, a questionnaire was addressed to all steam roads by the Depreciation Section of the Bureau of Accounts.

1922—The Depreciation Committee was unable to accept the theory as advanced when its report was returned, and again endeavored to have the report approved by the President's Conference Committee, but was unsuccessful except with respect to equipment.

As a result of this disagreement the Presidents' Conference Committee on January 6, 1922, took the following action: "Resolved, That it is the sense of this committee that depreciation charges be confined to equipment, and that it is the purpose of this committee, to whom this subject has been committed, to invite discussion and hearing before the appropriate body, the Interstate Commerce Commission, in furtherance of the principle expressed in this resolution, in connection with the interrogatory of the Interstate Commerce Commission, dated December 20, 1921."

1923—The Interstate Commerce Commission, under date of August 23, 1923, issued a report of the Bureau of Accounts, Depreciation Section, entitled: "Report of the Preliminary Investigation of Depreciation Charges in Connection with Steam Roads, and the Tentative Conclusions and Recommendations of the Depreciation Section for the Regulation of Such Charges."

In the notice preceding the report announcement was made of a public hearing upon the subject matter of the report to be held at the office of the Commission in Washington, D. C., beginning at 10 a. m., October 1, 1923, before Examiner Fowler, at which hearing opportunity would be afforded for the presentation of evidence. In addition to the matters discussed in the report of the Depreciation Section, the Commission requested consideration of five questions—stated in the notice.

This hearing was subsequently postponed from October 1, 1923, to November 19, 1923.

The subject of depreciation and the preliminary report were considered at a meeting of the Presidents' Conference Committee on October 9, 1923, and the following resolution was adopted unanimously.

"Resolved, That we reaffirm our former several resolutions on depreciation, and the judgment of this committee still is, that the charging of depreciaton on roadway and structural improvements should not be made obligatory, but be left optional under the accounting regulations of the Interstate Commerce Commission, or if the Commission feels obliged under the Transportation Act, 1920, to specify the particular classes of property upon which depreciation shall be charged, then, that it limit such classes to structures of such magnitude and cost, that the charging of the entire cost thereof to operating expenses at the time of retirement would render operating expense accounts for that year disproportionate as compared with other years."

The subject of Depreciation Charges in Connection with Steam Roads came up for hearing before Division 4 of the Interstate Commerce Commission on November 19-20-21 and 22, 1923. Testimony was given by witnesses on behalf of the Presidents' Conference Committee, to the general effect that it was not necessary to set up depreciation reserves for the purpose of equalizing retirements; but if the Commission thought the Act was mandatory (which was not admitted), that the depreciation accounts should be confined to the larger and more costly structures. Witnesses testified that there is no depreciation in the fixed property of an operated railroad as a whole so long as it is properly maintained and kept in condition for efficient operation.

Leave to intervene was given on petition presented by Carl D. Jackson, on behalf of the National Electric Light Association, and the American Gas Association; and by C. E. Williams for the Consolidated Gas Company of New York. The petition of the two former companies alleged, among other things: That the requirements for meeting retirement cost cannot be fixed by any mathematical formula applicable to railways or utilities generally, or by states, sections, or territorial divisions, nor will they be the same for any two companies operating in the same locality, and that requirements vary with every utility and locality and the amounts to be provided in so-called depreciation or retirement reserves must be determined after consideration of all the circumstances and conditions of each utility including the operating and financial conditions of each utility.

The petitioners further alleged that such facts should not be ignored and that the report and recommendations of the Bureau of Accounts, Depreciation Section, are impracticable.

1924—On April 18-19, 1924, argument on the subject of Depreciation Charges of Steam Railroad Companies and Depreciation Charges of Telephone Companies was held before the Interstate Commerce Commission. Argument was made on behalf of the Presidents' Conference Committee by W. G. Brantley, of Counsel, and Fred H. Wood, General Counsel of the Southern Pacific Company. Arguments were also made on behalf of the American Telephone and Telegraph Company, the independent telephone companies, by representatives of gas and electric companies, and the cities of New York and Chicago. The difference between the position of the carriers and that taken by the gas and electric companies was that the latter did favor a general small retirement fund for the purpose of equalizing retirements, while the carriers had never gone further than to suggest the accrual, at their own discretion, of retirement funds to cover large pieces of fixed property. During the two days of argument little was said about the railroads other than argument by counsel. City and State representatives spent most of their time in discussing telephone depreciation.

In connection with the argument, there was a situation which might have been embarrassing, but had been well handled. The Commission had joined for argument the two dockets relating to the Depreciation Charges of Steam Railroad Companies and that relating to Depreciation Charges of Telephone Companies. Commissioner Eastman had previously stated that he would like to find out why the telephone companies set up depreciation reserves while the railroad companies took the position that no depreciation reserves should be set on fixed physical property. When the argument was held, there was no conflict between the two interests, the relation being as to differences in the kind of properties.

1926—On November 2, 1926, the Interstate Commerce Commission announced its findings with respect to depreciable property of steam railroads in Order No. 15100, effective January 1, 1928, and prescribed the rules to govern the determination of depreciation charges as required by paragraph (5), section 20, of the Interstate Commerce Act. The order prescribes the classes of property for which depreciation accounting is required, and in the case of steam railroads includes thirty-six road accounts and eight equipment accounts.

The order relating to the steam railroads, prescribes, among other things, that the depreciation expense is to be based upon the original cost of property to the accounting company for that property coming into existence subsequent to June 30, 1914, while for that in existence as of that date, the Federal Valuation amounts are to be used. The carriers are given until September 1, 1927, to file with the Commission estimates, of the composite percentage rates applicable to the ledger value of the respective primary accounts. The percentage to be applied, however, with the approval of the Commission, may vary for different companies, dependent upon the individual views based upon their experience as to service lives, especially retirements. The amount of past accrued depreciation as of January 1, 1928, not previously accounted for, is required to be computed on a straight line basis, and the amount so estimated to be concurrently credited to the depreciation reserve and charged to a suspense account on the assets side of the balance sheet, which suspense account may be gradually extinguished by charges to Profit and Loss. Each carrier is also required to include in its annual report to the Commission, a concise statement showing by primary accounts, the extent, if any, to which ordinary maintenance of the property which it operates has been neglected or deferred during the year.

1927—The Presidents' Conference Committee met in New York on April 7, 1927, and gave consideration to the report and order of the Interstate Commerce Commission in re Depreciation Charges of Steam Railroad Companies, No. 15100.

On April 19, 1927, pursuant to a resolution of the Presidents' Conference Committee, a committee, consisting of Samuel Rea, Chairman, P. E. Crowley, Hale Holden, A. D. McDonald and Thos. W. Hulme, called on the Interstate Commerce Commission and requested that the effective date of Order No. 15100—Depreciation Charges of Steam Railroad Companies—be postponed for one year; and that a further hearing be granted on the Order with the understanding that the carriers would file a formal petition for rehearing not later than June 20th. Subsequently Commissioner Eastman agreed that the time for filing could be extended to July 5, 1927.

On May 6, 1927, an order of the Interstate Commerce Commission postponed the effective date of the order in No. 15100, Depreciation Charges of Steam Railroads, from January 1, 1928, to January 1, 1929.

On July 2, 1927, a petition for a rehearing was filed on behalf of the New York Central Lines.

On July 5, 1927, a petition for a rehearing was filed on behalf of the carriers by the Presidents' Conference Committee.

On July 11, 1927, the Interstate Commerce Commission ordered that Docket No. 15100—Depreciation Charges of Steam Railroad Companies—be reopened and assigned for further hearing Nov. 9, 1927. It was further ordered that respondent carriers shall file with the Commission on or before September 1, 1927, a statement setting forth specifically, and in detail, the matters in regard to which they desire to introduce evidence at the further hearing.

At a meeting of the Presidents' Conference Committee, held on July 27, 1927, a resolution was adopted providing for the preparation and presentation of the carriers' views and evidence at rehearing under Docket No. 15100, Depreciation Charges of Steam Railroad Companies.

On September 1, 1927, Counsel for the Presidents' Conference Committee filed with the Interstate Commerce Commission a statement on behalf of the carriers to accompany petition for rehearing.

Hearing in re Depreciation Order No. 15100 began on November 9, 1927, before Commissioner Eastman and Examiner Bunten, Chief of the Section of Depreciation, Bureau of Accounts. Prior thereto the Commission had issued an order—Ex Parte 91—Proposed Revision of Accounting Rules for Steam Railroads, stating that it had decided to make same the subject of a public hearing, and that it would hold such hearing in connection with that in No. 15100 and in re Depreciation Charges of Telephone Companies No. 14700; but that the records in those three proceedings would be kept separate.

At the request of the officers of the Accounting Association, and in view of the existing inter-relationship between Docket 15100 and Ex Parte 91, Counsel for Presidents' Conference Committee entered an appearance on behalf of that organization.

On behalf of the National Industrial Traffic League and for the National Council of the Traveling Salesman's Association an alternative plan of depreciation accounting, and also an alternative plan for the proposed revision of the accounting rules of steam railroads in Ex Parte 91, were offered as representing the views of these organizations.

On behalf of the Southern Pacific Company testimony was offered presenting their objections to the order from both a general and an accounting point of view. Seven witnesses offered testimony with respect to accounting, engineering and mechanical features. A. D. McDonald, of the Southern Pacific Company, said in part that: He thought the order "in its consequences, the most important and far-reaching decision ever issued by the Commission." That Congress did not expect or require the Commission to go to the extremes represented by Order No. 15100, and it was his hope that the Commission would defer action on the whole depreciation question until the fundamental questions involved were passed upon by the Supreme Court. He said that the testimony of the Southern Pacific would treat the case as an accounting one and not as a valuation one; and that the position of the Southern Pacific with respect to depreciation in valuation remained unchanged.

He also stated in substance that if the Commission decided they must proceed at this time to inaugurate a system of compulsory depreciation accounting for fixed properties, he recommended, among other things, that they continue the present accounting rules; confine the application of the order principally to structural accounts; and, for railroads having operating revenue over $100,000,000 annually, fix the minimum ledger value of $50,000.00 for a unit of property—other minimums to be fixed for other classes of railroads.

On behalf of the carriers represented by the Presidents' Conference Committee, Messrs. Ekin and Charske analyzed the order in detail. They pointed out the objections to the rewriting of the investment account as prescribed by finding 8 of the order, and the further sub-division between depreciable and non-depreciable property; the impossibility of estimating service lives with any degree of accuracy; the placing of the unknown factor of extraordinary repairs in the order; the impairment of credit that would result to the carrier by the setting up on the balance sheet of an item to represent the so-called past accrued depreciation; the unwarranted expense that would be incurred by the carriers in inaugurating and continuing depreciation accounting; and as to the requirement of the order that each year a statement of deferred maintenance be submitted.

Mr. Thomas confined his testimony to a criticism of the portion of the order relating to extraordinary repairs.

Mr. Downs denied the existence of any depreciation in the Illinois Central other than what might be included in deferred maintenance. He testified more particularly to the effect the order would have on credit and in a restriction of the power of management.

Messrs. Hand, Courtenay, Ripley, Cartwright, Willoughby, Leighty and Wiggins testified to the effect of the order from economic and engineering standpoints, and showed, by numerous specific examples, the difficulty or impossibility of forecasting service lives and obsolescence of fixed physical property.

In the course of his testimony Mr. Ekin pointed out that the result of the operation of finding 8 for twenty-seven Class 1 carriers would result in writing down the inventory of their depreciable accounts more than $780,000,000. He showed, based on the valuation data available, that the amount of past accrued depreciation not yet accounted for required to be set up would amount to about $2,790,000,000.

Mr. Ekin also made a supplemental statement near the close of the hearing, in which he said, in substance, that the requirement of the order as to past accrued depreciation, together with the other phases thereof, would require a large amount of depreciation to be charged to the profit and loss accounts twice. He said that two methods of accounting have been in effect, as prescribed by the Commission; first, a renewal basis, chargeable to operating expenses for track structures; and, second, a unit retirement basis for equipment. Through the order the track structure is to be separated into various elements such as ties, rail, etc., to be accounted for under the unit retirement method. From the examples which he cited in his testimony, he was of the opinion that if depreciation is to be currently accrued on road property, there would be a duplication of charges to operating expenses or to profit and loss, whether or not past accrued depreciation is set up in the accounts, unless suitable adjustment of the investment account is made.

1928—The Interstate Commerce Commission issued a notice under date of January 17, 1928, that the hearing on Docket 15100—Depreciation Charges of Steam Roads—would be resumed on March 14, 1928, before Commissioner Eastman and Examiner Bunten.

Further hearing in re Depreciation Order No. 15100 began on March 14, 1928, before Commissioner Eastman and Examiner Bunten.

Upon invitation of the Interstate Commerce Commission, Professor K. T. Healy, Research Associate in Transportation, Yale University, testified on the general subject of depreciation, and of his study of depreciation accounting and reserves maintained for depreciation by the Swiss Federal Railroad and the German Federal Railroad.

Mr. W. C. Wishart testified on behalf of the New York Central Lines with respect to past accrued depreciation, and the practical application of finding 8 of the Commission's Order No. 15100 to the New York Central Lines.

On behalf of the carriers represented by the Presidents' Conference Committee, Messrs. Cole and Bunting presented their objections to the order from an accounting viewpoint. Mr. Bunting analyzed the order in detail, presenting as evidence his experience to give practical effect to the accounting structure on the Illinois Central properties.

After cross-examination of various witnesses the hearing was adjourned to May 17, 1928, as subsequently announced by the Interstate Commerce Commission.

Further hearing in re Depreciation Order No. 15100 began on May 17, 1928, before Commissioner Eastman and Examiner Bunten. On behalf of the New York Central Lines, Messrs. Bassett, Carpenter and Porter testified to the impossibility of estimating service lives with any degree of accuracy. Cross-examination of witnesses proceeded until May 21, 1928, on which date the hearing was adjourned to June 14, 1928, for the purpose of enabling Mr. Charske to present an amended exhibit.

On June 18, 1928, hearing in re Depreciation Order No. 15100 was continued. Amended exhibit was submitted by Mr. Charske upon the request of Commissioner Eastman and received in evidence.

Under date of June 4, 1928, the Interstate Commerce Commission ordered, "That the seventh ordering paragraph of the Commission's order of November 2, 1926, be and it is hereby further amended by eliminating therefrom all reference to the latest date upon which operating steam railroad companies shall file with the Commission, estimates of composite percentage rates."

The Commission has indicated that there would be a resumption of the hearing later in the year.

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(3) REQUIREMENTS OF THE ORDER AND PROBABLE METHOD NECESSARY TO INAUGURATE AND CURRENTLY CARRY OUT THE PROVISIONS THEREOF

The ordering paragraphs of the order of November 2, 1926, in I. C. C. Docket No. 15100, are repeated herewith as these paragraphs briefly state the requirements, although the various findings and explanations in the report accompanying, and made a part of, the order, furnish more comprehensively the meaning and intent of these ordering paragraphs, all dates being left blank on account of being indefinitely deferred by an amending order:

1st Ordering Paragraph:

It Is Ordered, That all steam railroad companies subject to the Interstate Commerce Act shall, effective ...., institute depreciation accounting, as hereinafter prescribed, with respect to the following classes of common-carrier property, found in the accompanying report to be classes of property for which depreciation charges may properly be included under operating expenses:

Road:
- Underground power tubes.
- Tunnels and subways.
- Bridges, trestles and culverts.
- Elevated structures.
- Ties.
- Rails.
- Other track material.
- Ballast.
- Right-of-way fences.
- Snow and sand fences and snowsheds.
- Crossings and signs.
- Station and office buildings.
- Roadway buildings.
- Water stations.
- Fuel stations.
- Shops and engine houses.
- Grain elevators.
- Storage warehouses.
- Wharves and docks.
- Coal and ore wharves.
- Gas producing plants.
- Telegraph and telephone lines.
- Signals and interlockers.
- Power dams, canals, and pipe lines.
- Power plant buildings.
- Power sub-station buildings.
- Power transmission systems.
- Power distribution systems.
- Power line poles and fixtures.
- Underground conduits.
- Miscellaneous structures.
- Paving.
- Roadway machines.
- Shop machinery.
- Power plant machinery.
- Power sub-station apparatus.

Equipment:
- Steam locomotives.
- Other locomotives.
- Freight train cars.
- Passenger train cars.
- Motor equipment of cars.
- Floating equipment.
- Work equipment.
- Miscellaneous equipment.

Provided, That in case a steam railroad company can show that the service life of its property is dependent upon a particular source of traffic, upon exhaustion of which the operation of the property for common-carrier purposes must be abandoned, and that the time of such exhaustion can be predicted with a reasonable degree of accuracy, then the entire property of such railroad may be classed as depreciable, in which case, however, the depreciation due to this particular factor shall be provided for through a special amortization account, instructions as to which will hereafter be given.

2nd Ordering Paragraph:

That in the application of this order the terms "service life," "service value," "net salvage value," "extraordinary repairs," "straight-line method," and "ledger value" shall be construed in accordance with the definitions and explanations given therefor in the accompanying report.

3rd Ordering Paragraph:

That depreciation accounting as referred to in this order shall mean:

(a) The charging to operating expenses and the crediting to a depreciation reserve during the service life of the property, as hereinafter provided, of amounts which will approximate the loss in service value not restored by current maintenance, other than extraordinary repairs, and incurred in connection with the consumption or prospective retirement of property in the course of service from causes against which the carrier is not protected by insurance, which are known to be in current operation, and whose effect can be forecast with a reasonable approach to accuracy; and

(b) The crediting of the ledger value of property at time of retirement to the appropriate primary road and equipment accounts and the charging to the appropriate primary accounts under operating expenses of the service value of property when retired and of the full cost of extraordinary repairs when made, with concurrent release from the depreciation reserve by charges thereto and concurrent credit to the appropriate credit accounts which shall be provided for that purpose in operating expenses under general accounts "Maintenance of way and structures" and "Maintenance of equipment," of such service value and of that portion of the cost of such extraordinary repairs which, under the provisions of this order, is chargeable to the reserve.

4th Ordering Paragraph:

That the annual charges to operating expenses for currently accruing depreciation shall be computed, as hereinafter provided, at such percentage rate of the ledger value of the property in question that the service value may be distributed under the straight-line method in equal annual charges to operating expenses during the estimated service life of the property. Annual charges so computed shall be reduced to a monthly basis by dividing by 12.

5th Ordering Paragraph:

That all depreciation charges to operating expenses and concurrent credits to the depreciation reserve shall be made monthly in conformity with the group plan of accounting for depreciation, as explained in the accompanying report and as hereinafter provided, and in determining such monthly charges and credits the annual percentage rates shall be applied to the total ledger value, as of the first of each month, of the respective primary accounts covering the classes of property hereinbefore specified, and the result divided by 12.

6th Ordering Paragraph:

That in determining the monthly depreciation charges to operating expenses and the corresponding credits to the depreciation reserve, a composite percentage rate shall be computed for each of the primary accounts in the classification of road and equipment covering the classes of property hereinbefore specified; that such composite rate shall be based upon estimated service values and service lives developed by a study of the carrier's history and experience and such engineering information as may be available with respect to future prospects and shall produce a charge to operating expenses for the primary accounts, where more than one class of property is covered by the account, equal to the sum of the amounts that would otherwise be chargeable for each of the various classes; and that such composite rate shall be ascertained at the beginning of the year and its use continued throughout the year unless the changes during the year in the relative quantities of the various classes of property included in the primary account, where more than one class is included, are sufficient to produce a serious discrepancy in the reserve, in which event an appropriate change in the composite rate shall be made, subject to the approval of the commission.

7th Ordering Paragraph:

That, not later than ...., each operating steam railroad company subject to the act shall file with the Commission estimates of the composite percentage rates applicable to the ledger values of the respective primary accounts, in the classification of road and equipment, covering property owned, leased, or operated under contract by such company, such estimates to be arrived at in the manner hereinbefore prescribed and accompanied by a sworn statement showing the bases therefor and the methods employed in their computation. Following an office check of such data the composite percentage rate of depreciation which shall be charged with respect to each such primary account will be prescribed for each company by temporary order of the Commission subject to subsequent modification from time to time in accordance with the procedure set forth in the accompanying report.

8th Ordering Paragraph:

That charges to the depreciation reserve incident to extraordinary repairs shall be made as follows:

(a) Where a longitudinal section of a continuous structure, such as a long trestle, right-of-way fence, snowshed, wire line, etc., is renewed in its entirety, or where parts of such structures of a particular type are replaced by the substitution of parts of an improved type or design, such as the substitution of concrete for wooden posts in a fence or of copper wire for steel wire in a telephone or telegraph line, the ledger value of the property so retired, determined by taking a proper proportionate part of the total ledger value of the continuous structure, shall be credited to the investment account and concurrently a similar amount, after deducting net salvage value, shall be released from the depreciation reserve by charge thereto and credit to the appropriate credit account or accounts in operating expenses; and

(b) Where the total cost of repairs to a particular unit of property exceeds a certain minimum sum and also exceeds a certain minimum percentage of the ledger value of the unit, an amount equal to the cost of such repairs in excess of such minimum percentage shall be released by charge to the depreciation reserve and concurrent credit to the appropriate credit account or accounts in operating expenses; Provided, however, that if the total cost of repairs exceeds a certain maximum percentage of the ledger value, the unit shall be deemed to have been retired from service and shall be accounted for accordingly;

and that the minimum and maximum percentages and minimum sum referred to in (b) above shall be those specifically prescribed hereafter in the manner indicated in the accompanying report.

9th Ordering Paragraph:

That upon the retirement of a unit of property an amount equal to its service value shall be released by charge to the depreciation reserve and shall be credited to the appropriate credit account, hereinbefore required, under operating expenses.

Provided, That if the cause of retirement is not a recognized factor in depreciation, as explained in the accompanying report, but is a cause against which the carrier is insured, the depreciation reserve shall be credited with the full amount of insurance recovered; and

Provided further, That if the cause of the retirement is not a recognized factor in depreciation and the loss is not covered by insurance, the carrier may, upon proof that the charge to the depreciation reserve will result in undue depletion thereof, and with the approval of the Commission, increase the amount charged each year to operating expenses on account of depreciation, over a period of years in the future, to the extent necessary to make good such depletion.

10th Ordering Paragraph:

That in determining the amounts to be respectively credited to that primary road and equipment accounts and charged to the material and supplies account and to the depreciation reserve in the case of retirement of property, amounts for specific units shall be used so far as practicable; but that where this is impracticable because of the relatively large number and small size of the units, average amounts shall be used.

11th Ordering Paragraph:

That each steam railroad company subject to the act that has not yet assigned appropriate amounts to the primary road and equipment accounts covering property for which depreciation accounting is herein prescribed, including improvements on leased railway property, shall do so not later than ....; that such companies as have already made an assignment of investment to the primary accounts shall redistribute the same; that such distribution or redistribution and the accounting in connection therewith shall be accomplished in accordance with finding (8) of the accompanying report; and that the remainder of the amount representing the carrier's investment in road and equipment shall be carried in sub-accounts which will be provided for in the Commission's classification for inclusion of the carrier's unassigned investment in road and equipment.

Provided, That such carriers as desire to do so may, upon application to and approval by the Commission, extend the distribution or redistribution in accordance with said finding (8) to other primary accounts, with the exception of that covering land, thereby reducing the amount to be carried in the sub-accounts covering the unassigned investment.

Provided further, That in all instances where the assignment of amounts to the primary accounts, as above provided, is governed by paragraph (b) of finding (8), complete information pertaining thereto shall be submitted to the Commission and such amounts shall not be spread upon the books until the Commission has indicated its approval of the same.

12th Ordering Paragraph:

That each steam railroad company shall estimate, in accordance with the principles set forth for the determination of currently accruing depreciation, the amount of past accrued depreciation as of ...., for all property for which depreciation accounting is herein prescribed; shall credit to the depreciation reserve such portion of the same as has not previously been so accounted for; and shall concurrently debit a corresponding amount to a suspense account on the assets side of the balance sheet for clearance later in accordance with such instructions as may hereafter be issued by the Commission.

13th Ordering Paragraph:

That each operating steam railroad company shall keep a record of property retirements which shall reflect the service life and percentage of salvage value of each important class of property hereinbefore specified; shall maintain in convenient and accessible form engineering data bearing on prospective service lives; and shall be prepared at any time upon direction by the Commission to compute and submit, for the Commission's approval, new percentage rates to take the place of those based upon service lives or percentages of salvage value found to be inaccurate.

14th Ordering Paragraph:

That each operating steam railroad company shall include in its annual report to the Commission a concise statement showing by primary accounts the extent, if any, to which ordinary maintenance of property which it operates has been neglected or deferred during the year, such statements to be subscribed and sworn to by an official of the company having knowledge of the facts.

15th Ordering Paragraph:

That with respect to property used for common-carrier purposes which is leased or operated under contract, operating steam railroad companies shall include in operating expenses charges and credits for depreciation, extraordinary repairs, and retirements upon the same basis as for owned property, and shall maintain the same records of service lives, salvage values, etc., and make the same reports concerning neglected or deferred maintenance as are required for owned property.

16th Ordering Paragraph:

That all accounting procedure specifically provided in this order shall be subject to such modification as may be necessary to bring it into harmony with any accounting classifications subsequently prescribed by the Commission.

An analysis of the purpose and probable use of the Depreciation Order indicates that the Commission contemplates the use of the data collected in connection with the Federal Inventory of railroads as a starting point, and with this data blend the amounts that have been set up in the Investment in Road and Equipment accounts of the carriers since the present accounting classifications were effective on July 1, 1914, with the exception that the amounts for equipment values may be derived on a somewhat different basis. There are a number of radical departures from previous accounting requirements injected into this system of accounting that will be commented upon later.

The purpose and results of the accounting under the Depreciation Order are primarily for the purpose of creating reserves by current charges to Operating Expenses for future retirements, and to take care of major restorative repairs to existing railway property.

It is further obvious that the Commission desires to set up in the depreciation reserves, the so-called "used up" value of railroad property or past accrued depreciation. In addition to these obvious uses, there is some speculation that the depreciation system of accounting will be used for recapture and rate-making purposes, by using this so-called "used up" value as measured by the extent of the amounts stated in the depreciation reserves, in arriving at the depreciated value of railway property. At this point it can be stated that any reserves developed by the processes required by this Depreciation Order will naturally be in excess of past accrued depreciation, that would be developed by the usual valuation method of ascertaining the "condition per cent" of the property from field inspection.

To carry out the provisions of the order requires a complete revision of the carriers' Investment in Road and Equipment Account, as it is one of the requirements to substitute the Commission's inventory values for retirements, rather than those amounts used heretofore by the carriers; also, it is another requirement that amounts charged to Operating Expenses for certain renewals be reinstated in the Investment Account, this being particularly true for those primary accounts pertaining to the track structure. The processes that are necessary to inaugurate the Commission's depreciation accounting scheme are quite involved and complicated in the establishment of a depreciation base, but there are a number of other complex features, such as service values, service life, past accrued depreciation and annual percentage rates. There is a very important feature that is not ordinarily present in the usual commercial scheme of depreciation accounting, in that an attempt is made to take into consideration the restorative effect on service lives, of major repairs, but it is believed after careful study that the provisions of this order for this feature of "extraordinary repairs" prove to be inadequate and incomprehensive.

In the following will be discussed a description of the principal characteristics of the order and probable methods necessary for carriers to follow, to carry out the requirements:

1st Ordering Paragraph

> Steam Railroad Companies to institute depreciation accounting, effective January 1, 1928 (effective date postponed to January 1, 1929, by subsequent order and later postponed indefinitely).

This states that depreciation accounting should be applied to 36 of the present 47 primary accounts for fixed property, and all of the present primary accounts for equipment, of the Investment in Road and Equipment Classification. These 36 primary accounts for fixed property and the 8 primary accounts for equipment are designated as "primary depreciable accounts." The first consideration to be given to inaugurating this system of depreciation accounting is the obvious need of subdividing the 44 primary depreciable accounts into sub-classes, and to illustrate what seems to be necessary, there is attached a statement showing suggested sub-divisions for each primary account. This statement is tentative, as it has not been established from actual experience, but it indicates the necessity of a logical sub-division of various classes of property to permit grouping items of a like kind together. The tentative statement of sub-classes of property is shown in Exhibit "A."

A second important feature that must be given consideration before attempting to inaugurate this system of depreciation accounting is a possible revision of valuation sections necessary to conform with the Engineering Report in the final valuation of the Commission.

It is believed that the minimum number of valuation sections should be used in order to simplify the work, and careful consideration should be given before undertaking the immense amount of detailed accounting and engineering work that is required to establish a depreciation base under the requirements of the order.

Another important item to be given consideration on the part of certain carriers is whether any property will come under the amortization provision, and the desirability of amortizing the service value of the property rather than to account for it under the depreciation plan.

2nd Ordering Paragraph

> Provides that service life, service value, salvage value, extraordinary repairs, straight-line method, and ledger value be construed in accordance with definition and explanations in the depreciation report.

This provision covers the entire field of depreciation accounting, and comments are specifically made concerning each of these important factors under subsequent paragraphs of the order.

3rd Ordering Paragraph

> Requires charging to Operating Expenses and crediting Depreciation Reserves loss in service value not restored by current maintenance.

The ledger value of the property when retired subsequent to depreciation accounting, is to be credited to the Road and Equipment Accounts and charged to primary accounts under Operating Expenses, with a concurrent debit to the Depreciation Reserve and credit to Operating Expenses so as to show the accounting comparable with that prior to the establishment of depreciation accounting.

This part of the order is, in a general way, a definition of the intent of the Depreciation Order. While the language of this clause is obvious, it is believed to be in error in using the term "service value" in the phrase ".................... of the service value of property when retired ...." It is believed that the language should read "service value, excluding the element of extraordinary repairs."

4th Ordering Paragraph

> Annual charges to Operating Expenses for currently accruing depreciation to be computed from composite percentage rate of the ledger value and accounted for monthly on the basis of one-twelfth of the annual charge.

This provision provides that the charges to Operating Expenses shall be determined by the annual percentage rate of ledger value for each primary depreciable account, and that the annual charges shall be reduced to a monthly basis by dividing by twelve. The charge to Operating Expenses determined as provided for is the one final purpose of depreciation accounting and is therefore the crux of the whole subject. In connection with subsequent ordering paragraphs, there are given comments for each important factor of the Commission's entire depreciation scheme.

5th Ordering Paragraph

> Group plan of depreciation accounting based on composite percentage rates, applied to ledger value, as of the first of each month by each primary account.

This requires a new plan of accounting for depreciation, in that monthly charges and credits affecting Operating Expenses and Depreciation Reserve must be determined as of the 1st of each month for each of the respective primary accounts on the basis of the total ledger value as of the first of that month.

This paragraph deals with the current depreciation accounting procedure and while no detailed study has been made of a current depreciation accounting system, yet attention is directed to it being impracticable to handle as the order requires, on any actual basis. A certain length of time must elapse after the reporting of physical work to close the accounts for any special project, and this has been recognized in previous orders of the Commission, namely, Valuation Order No. 3, 2nd Revised Issue, which gives a period of from sixty to ninety days to file certain reports. For large construction projects it is generally recognized that even sixty or ninety days is entirely insufficient to close the accounting.

This is an impracticable feature of the order and should be modified so that a system of averages can be used, providing for adjustments in subsequent months. This plan should prove satisfactory and will meet with all the other requirements of the order.

In considering the practical application of the principles outlined in this ordering paragraph, attention must be given to the fact that the order is silent as to whether work under construction or incomplete work is to be included in the depreciation plan of accounting, but it is believed that any property in the process of construction, or in an incomplete state, should be excluded from any scheme of depreciation accounting, as it is manifestly improper to commence depreciation on something that is not used in transportation service.

6th Ordering Paragraph

> Composite percentage rate to be based on estimated service values and service lives developed from study of carrier's history, plus influences account future possibilities. Percentage rate to be ascertained at beginning of year and continued throughout year unless changed upon approval of the Commission.

This provision involves practically all the various other provisions of the order, including service lives, service values and ledger values, detailed provisions for which are referred to elsewhere. Several methods may be used in the computation of these composite percentage rates for the various primary depreciable accounts, as the real problem is to arrive at an estimated annual amount of depreciation of the property for each primary account, and the percentage rate that such an annual amount bears to the total ledger value of the property in the primary account.

As this new accounting system is inaugurated in the midst of life of various units of railroad property, there is a past life and a future life as well as a combined past and future life, and there is present the question as to whether any proportion of any service value assigned or any service value relating to the past should be allowed to influence the percentages to be used in the future, providing that the method used is given due consideration in setting up the estimate for the amount of past accrued depreciation.

The most simple and apparent method is that of computing these rates on the basis of total life, but there is some doubt as to the eventual working out of this method, especially, considering the probable changes that will be necessary in these rates as conditions change, etc.

7th Ordering Paragraph

Recommended composite percentage rates applicable to ledger values for each primary account to be filed with the Commission, accompanied by sworn statements showing bases and methods.

Requires the filing of sworn statements showing bases and methods of determining composite percentage rates. The order, as issued, provided for this filing not later than September 1, 1927, which date was extended to September 1, 1928, and then by subsequent amending order it was postponed indefinitely.

In accordance with this provision it is obvious that a carrier should prepare the underlying data in a systematic manner and that the actual, final computations should be worked out in such a manner as to permit filing with the Commission in order to clearly indicate the procedure followed. The forms used for these purposes, beyond any question, should be of uniform size, such as 11" x 8½", 11" x 17", or multiples thereof.

8th Ordering Paragraph

Defines "extraordinary repairs" and provides that charges shall be made to the Depreciation Reserve for this class of work.

This feature is an element of service value and requires the use of certain minimums and rules which the order has failed to provide, although indicating that such rules and regulations will be later provided for. In most cases records have not been maintained by carriers to permit of the determination of the cost of repair work in the past. Some study, however, should be made of the cost of past repair work to the greatest extent possible for the determination of an estimate of the annual cost of such repair work applicable for each sub-class of property. Future probability should, of course, be given due consideration in making this estimate.

Various studies and analyses indicate that this feature, if subject to the minimum intimated in the order, will be of relatively small consequence, whereas the detailed work required in complying with these provisions will be extremely burdensome upon all carriers. In fact, this burden will be so great as in itself to make this feature impracticable.

9th Ordering Paragraph

> Provides that Operating Expenses will be credited and the Depreciation Reserve debited, with an amount equal to the service value, when a unit of property is retired.

This requires the maintenance of a comparison by primary accounts with the past accounting statistics, following the institution of depreciation accounting, but this method will fail to give correct comparisons. The principal reason why his provision is deficient is because of the entirely different method of accounting through Investment in Road and Equipment for the cost of renewals of "Ties," "Rail," "Other Track Material" and "Ballast," whereas in the past the replacement theory of charging renewals to Operating Expenses was a mandatory accounting requirement.

Service value is defined in the order as "ledger value," "extraordinary repairs," and "net salvage value." The term "service value" as used in this paragraph is erroneous, as the accounting entry referred to is obviously intended to offset the charge made to appropriate primary accounts under Operating Expenses from the retirement of property, which will include only the elements of ledger value, plus or minus net salvage value.

10th Ordering Paragraph

> Average amounts may be used in arriving at credits to Investment in Road and Equipment and charges to the Depreciation Reserve and Materials and Supplies on retirement of small items of property.

Provides that average amounts shall be used in depreciation accounting when it is impracticable to determine the amounts for specific units in connection with the retirement of small items of property, but in a practical application there must be the same detailed accounting for small items of property as for large; accordingly there are no beneficial effects from this provision, as ledger values must be established, made up of large and small items, each of which must be included in the depreciation base in a similar manner.

11th Ordering Paragraph

> Re-distribution of the Investment in Road and Equipment Accounts for the purpose of depreciation accounting.

This requires a re-statement of the Investment Account, in accordance with Finding No. 8 of the report accompanying the Order, and the text is inadequate and entirely too indefinite to describe what is desired, but following a few principles that are expounded, the intent of the Order seems to require that certain re-stated values be set up under the depreciable primary accounts, which re-statement may be extended to all other accounts except "Land," upon the approval of the Commission, and that the remaining undistributed differences be set up as an unassigned investment item, providing that this is not an inadequate quantity, in which case a scaling down process of the re-stated amounts is required. Whether the effect of the mandatory re-statements on net investment values should be taken into consideration in measuring the adequacy or inadequacy of the unadjusted item remaining is not stated.

Apparently the provisions for the scaling down process are on account of property acquired by purchase at reduced values, in an attempt to avoid charges being made to Operating Expenses based on investment values in excess of actual cost to the operating company. However, by its indefiniteness, a very unsatisfactory situation is created which undoubtedly should be clarified before this provision of the Order can be complied with.

12th Ordering Paragraph

Provides for the determination of past accrued depreciation and accounting required.

It is required that an estimate be made of the amount of past accrued depreciation, as of the inauguration of the depreciation accounting, based on the principles set forth in the report accompanying the order, i. e., on a straightline basis. This necessitates the setting up of amounts in the depreciation base by ages, in order to permit of the allocation of the total service value between the past and future for each class of property. Amounts thus allocated as past accrued depreciation will be tremendous and excessive.

13th Ordering Paragraph

Future records to be maintained to reflect the adequacy or inadequacy of composite percentage rates.

A carrier is required to maintain future records to reflect the adequacy or inadequacy of composite percentage rates and this is a feature relating to current depreciation accounting; however, the entire system of records used in the current work for this purpose must be consistent and a continuation of those upon which the inauguration is based, and it is an undertaking of considerable magnitude at any time to analyze the adequacy or inadequacy of the rates for any one depreciable primary account, as innumerable computations and summaries must be made and drawn off from the system of records.

This feature should be given a great amount of consideration before deciding upon the exact method to be followed in computing such composite percentage rates, as one method over another may require a less complicated accounting system.

14th Ordering Paragraph

Sworn report to be made to Commission for neglected or deferred maintenance.

The report required for neglected or deferred maintenance, by this provision, is probably of considerable importance and appears to be unlike that used to discuss over or under maintenance incident to Federal Control, in that neglected or deferred maintenance, as referred to here, probably means that amounts are not used as contemplated when making credits to Depreciation Reserves by use of composite percentage rates, determined from experience with carrier's past history. It probably means that if a carrier neglected to maintain a certain ratio of tie or rail renewals that there can be considered neglected or deferred maintenance, and the reason why this work was not done will have to be shown in a sworn report, whether or not it is maintenance or whether material is not available and other such similar circumstances that obtain.

It may be that the measure of neglected or deferred maintenance can be the condition per cent determined from the detailed figures set up in the depreciation base after making deduction for new property. If a complete analysis is made in great detail, deferred maintenance is a matter difficult for a carrier to handle until long after the close of any one year, and unless broadly handled is an impracticable matter.

15th Ordering Paragraph

Depreciation accounting applicable to property leased or operated under contract.

This provision of the Order seems to cover all property leased or operated under contract. It is believed that a modification should be made for such property as leased equipment or other property on which the rental payments include the element of depreciation.

16th Ordering Paragraph

Accounting procedure in the Order subject to modifications.

This provision intimates that a considerable latitude will be taken to make future changes, whereas the inauguration of a system of depreciation accounting, such as required by the Order, involves a great mass of detailed accounting, practically all of which is vitally involved in the ultimate result, and, furthermore, is connected with current operation of the accounting system. If any drastic changes are ordered they may prove very expensive and cause considerable delay. The processes should be fixed prior to the inauguration of the accounting scheme and adhered to with no retroactive features. The tremendous volume of detailed work required will not permit of changes of any consequence except at great expense and burden upon carriers.

It is very important that carriers themselves be certain of all the various features before a great amount of work is concluded on account of the inter-relation of each feature with the whole.

GENERAL

In a study of the Commission's plan of depreciation accounting, consideration has been given to the extent and magnitude of the work required of carriers. The first step in complying with the Order is the inaugural work, or the preparation and effort that must be made to get ready for instituting depreciation accounting. This preparatory work involves a long and detailed investigation of the various peculiar phases of depreciation accounting as applied to the railway industry and the assembly of a great amount of data, with consequent expense to the carriers. In addition much time will be required to carry out the provisions by the large carriers.

The second step is the current accounting methods which commence on a date to be prescribed by the Commission in the future. An entirely different organization and method of procedure is necessary for the current operation. The only similarity with the inaugural work is maintaining the depreciation base up-to-date, and a continuation of studies of service lives and values in order to be in a position to verify the correctness of composite percentage rates, and to be in position to make an application for a change when circumstances require it.

The Commission has now served Supplements No. 4 and No. 5 to Valuation Order No. 3, Second Revised Issue, and Valuation Order No. 25, on certain carriers which require the use of a new "List of Units," and the preparation and filing of B.V. Form No. 588 for bringing the basic valuation down to date; also requirements as to revision of the original accounting report. Certain of the work in connection with the preparation and filing of B.V. Form No. 588 is closely allied to the accounting process it is necessary to follow in the inaugural work of the depreciation order. It is important that consideration be given by carriers to avoid a duplication of effort in handling these two tasks and to organize the depreciation work, or the work in connection with B.V. Form No. 588, to avoid unnecessary effort and expense.

The Committee, in its study of the subject of depreciation accounting, has given consideration to the use of various forms and mechanical means that might be used to save much detailed accounting work. It is believed that much labor and time can be eliminated by the use of mechanical appliances.

After a complete study of the subject, the Committee has arrived at certain conclusions, which are enumerated below:

Conclusions

(1) The Order involves both engineering and accounting work and, as it is impracticable to segregate the work of each, compliance with the Order should be handled as a unit.

(2) To inaugurate and currently handle the requirements of the Order involves a radical revision of the mandatory accounting regulations heretofore in effect and imposes a large expense and burden upon carriers. It is the belief of the Committee that the effect of depreciation accounting, as outlined in the Order, will result in further increased annual charges to carriers' Operating Expenses and that if the amount of past accrued depreciation, not accounted for, as required to be set up by the present Order, is cleared by a charge to Profit & Loss, in many instances, the Profit & Loss account of carriers will be entirely extinguished.

(3) It is impracticable to comply with the provisions prescribed for accounting for extraordinary repairs.

(4) The filing of an annual report of deferred maintenance, if any, is an impracticable and unnecessary provision.

(5) The Committee believes that the Commission's Orders, Supplement No. 4 and Supplement No. 5 to Valuation Order No. 3, Second Revised Issue, and Valuation Order No. 25, are closely related to the depreciation accounting scheme of the Commission as is set out in the Depreciation Order Docket No. 15100, and that the work of complying with these orders should be synchronized and co-ordinated to the fullest extent, although realizing that there are two separate bureaus of the Commission involved, having different viewpoints and purposes to accomplish.

Recommendations for Future Work

The Committee recommends that the subject be continued so that in the event of any future developments, such as the issuance of a modified order or the establishment of a definite date of compliance with the existing order, more detailed and definite information can be disseminated as to methods, forms and other facts.

Exhibit A

SUGGESTED CLASSIFICATION OF PROPERTY FOR STATING OF DEPRECIATION BASE, WHICH MAY BE USED IN COMPLYING WITH INTERSTATE COMMERCE COMMISSION DEPRECIATION ORDER, DOCKET NO. 15100

Instructions for Use

The following classes of property are to be used in recording the re-stated Investment Account as a Depreciation Base, required by I.C.C. Order No. 15100. Where classification of property is not provided for in any account the appropriate classification should be selected from the list covering similar property in other accounts; additional sub-classes should not be used except with the proper authorization. Important major items are to be reported individually. Each class under each account should be identified with a class number, as shown below.

CLASSIFICATION

Account 1—Engineering

Non-Depreciable

Account 2—Land

Non-Depreciable

Account 3—Grading

Non-Depreciable

Account 4—Underground Power Tubes

Sub-class 4-1, Individual Items

Account 5—Tunnels and Subways

Sub-class 5-1, Individual Items

Account 6—Bridges, Trestles and Culverts

Sub-class 6- 1 Individual Items
Sub-class 6- 2 Open Deck Trestles—Treated
Sub-class 6- 3 Open Deck Trestles—Untreated
Sub-class 6- 4 Open Deck Trestles—Bents Treated—Deck Untreated
Sub-class 6- 5 Ballast Deck Trestles—Treated
Sub-class 6- 6 Ballast Deck Trestles—Untreated
Sub-class 6- 7 Ballast Deck Trestles—Bents Treated—Deck Untreated
Sub-class 6- 8 Ballast Deck Trestles—Masonry Bents—Deck Treated
Sub-class 6- 9 Ballast Deck Trestles—Masonry Bents—Deck Untreated
Sub-class 6-10 Combination Masonry and Steel Bridges
Sub-class 6-11 Combination Timber and Steel Bridges
Sub-class 6-12 Concrete Pile and Pier Trestles
Sub-class 6-13 Culverts—Masonry Boxes and Arches
Sub-class 6-14 Culverts—Reinforced Concrete and Cast Iron Pipe
Sub-class 6-15 Culverts—Miscellaneous (including wood boxes)
Sub-class 6-16 Rip Rap

Account 8—Ties

Sub-class 8- 1 Individual Items
Sub-class 8- 2 Cross-Ties—Creo., main track
Sub-class 8- 3 Cross-Ties—Creo. S. H., main track
Sub-class 8- 4 Cross-Ties—Zinc, main track
Sub-class 8- 5 Cross-Ties—Zinc S. H., main track.
Sub-class 8- 6 Cross-Ties—Untreated, main track
Sub-class 8- 7 Cross-Ties—Untreated S. H., main track
Sub-class 8- 8 Switch Ties (incl. scale, xing and miscl. ties)—Treated, main track
Sub-class 8- 9 Switch Ties (incl. scale, xing and miscl. ties)—Treated, S. H., main track
Sub-class 8-10 Switch Ties (incl. scale, xing and miscl. ties)—Untreated, main track
Sub-class 8-11 Switch Ties (incl. scale, xing and miscl. ties)—Untreated, S. H., main track
Sub-class 8-12 Bridge Ties—Treated, main track
Sub-class 8-13 Bridge Ties—Treated S. H., main track
Sub-class 8-14 Bridge Ties—Untreated, main track
Sub-class 8-15 Bridge Ties—Untreated S. H., main track
Sub-class 8-16 Cross-Ties—Creo., other tracks
Sub-class 8-17 Cross-Ties—Creo. S. H., other tracks
Sub-class 8-18 Cross-Ties—Zinc, other tracks
Sub-class 8-19 Cross-Ties—Zinc S. H., other tracks
Sub-class 8-20 Cross-Ties—Untreated, other tracks
Sub-class 8-21 Cross-Ties—Untreated S. H., other tracks
Sub-class 8-22 Switch Ties (incl. scale, xing and miscl ties)—Treated, other tracks
Sub-class 8-23 Switch Ties (incl. scale, xing and miscl. ties)—S. H., other tracks
Sub-class 8-24 Switch Ties (incl. scale, xing and miscl. ties)—Untreated, other tracks
Sub-class 8-25 Switch Ties (incl. scale, xing and miscl. ties)—Untreated S. H., other tracks
Sub-class 8-26 Bridge Ties—Treated, other tracks
Sub-class 8-27 Bridge Ties—Treated S. H., other tracks
Sub-class 8-28 Bridge Ties—Untreated, other tracks
Sub-class 8-29 Bridge Ties—Untreated S. H., other tracks

Account 9—Rail

Sub-class 9- 1 Individual Items
Sub-class 9- 2 90 lb. and over—New, main tracks
Sub-class 9- 3 90 lb. and over—Relay (incl. re-rolled and sawed), main tracks
Sub-class 9- 4 75 lb. to 85 lb.—New, main tracks
Sub-class 9- 5 75 lb. to 85 lb.—Relay (incl. re-rolled and sawed), main tracks
Sub-class 9- 6 74 lb. and under—New, main tracks
Sub-class 9- 7 74 lb. and under—Relay (incl. re-rolled and sawed), main tracks
Sub-class 9- 8 90 lb. and over—New, other tracks
Sub-class 9- 9 90 lb. and over—Relay (incl. re-rolled and sawed), other tracks
Sub-class 9-10 75 lb. to 85 lb.—New, other tracks
Sub-class 9-11 75 lb. to 85 lb.—Relay (incl. re-rolled and sawed), other tracks
Sub-class 9-12 74 lb. and under—New, other tracks
Sub-class 9-13 74 lb. and under—Relay (incl. re-rolled and sawed), other tracks

Account 10—Other Track Material

Sub-class 10- 1	Individual Items
Sub-class 10- 2	Rail Fastenings, etc. (incl. rail jts., bolts, nutlocks, anti-creepers and rail braces), main track
Sub-class 10- 3	Rail Fastenings, etc. (same as above), S. H., main track
Sub-class 10- 4	Crossings, Railroad (O. H., Bessemer and Manganese), main track
Sub-class 10- 5	Crossings, Railroad (same as above), S. H., main track
Sub-class 10- 6	Frogs and Switches (all kinds, incl. guard rail cpt.), main track
Sub-class 10- 7	Frogs and Switches (same as above), S. H., main track
Sub-class 10- 8	Curve and Bridge Guard Rails, main track
Sub-class 10- 9	Curve and Bridge Guard Rails S. H., main track
Sub-class 10-10	Tie Plates and Spikes, main track
Sub-class 10-11	Tie Plates and Spikes, S. H., main track
Sub-class 10-12	Miscl. Track Material (incl. switch stands, lamps, locks, bumping posts, derails and rail rests), main track
Sub-class 10-13	Miscellaneous Track Material (same as above), S. H., main track
Sub-class 10-14	Rail Fastenings, Etc. (incl. rail joints, bolts, nutlocks, anti-creepers and rail braces), other tracks
Sub-class 10-15	Rail Fastenings, Etc. (same as above), S. H., other tracks
Sub-class 10-16	Crossings, Railroad (O. H., Bessemer and Manganese), other tracks
Sub-class 10-17	Crossings, Railroad (same as above), S. H., other tracks
Sub-class 10-18	Frogs and Switches (all kinds, incl. guard rails cpt.), other tracks
Sub-class 10-19	Frogs and Switches (same as above), S. H., other tracks
Sub-class 10-20	Curve and Bridge Guard Rails, other tracks
Sub-class 10-21	Curve and Bridge Guard Rails—S. H., other tracks
Sub-class 10-22	Tie Plates and Spikes, other tracks
Sub-class 10-23	Tie Plates and Spikes—S. H., other tracks
Sub-class 10-24	Miscl. Track Material (incl. switch stands, lamps, locks, bumping posts, derails and rail rests), other tracks
Sub-class 10-25	Miscellaneous Track Material (same as above), S. H., other tracks

Account 11—Ballast

Sub-class 11- 1	Individual Items
Sub-class 11- 2	Crushed Stone, main tracks
Sub-class 11- 3	Screenings, Stone, Slag and Chatts, main tracks
Sub-class 11- 4	Gravel, main tracks
Sub-class 11- 5	Cinders, main track
Sub-class 11- 6	Sand, main tracks
Sub-class 11- 7	Crushed Stone, other tracks
Sub-class 11- 8	Screenings, Stone, Slag and Chatts, other tracks
Sub-class 11- 9	Gravel, other tracks
Sub-class 11-10	Cinders, other tracks
Sub-class 11-11	Sand, other tracks

Account 12—Track Laying and Surfacing

Non-Depreciable

Account 13—Right-of-Way Fences

Sub-class 13- 1 Individual Items
Sub-class 13- 2 Fences
Sub-class 13- 3 Cattle Guards
Sub-class 13- 4 Masonry Wall Fences

Account 14—Snow and Sand Fences and Snowsheds

Sub-class 14- 1 Individual Items
Sub-class 14- 2 Fences

Account 15—Crossings and Signs

Sub-class 15- 1 Individual Items
Sub-class 15- 2 Paving (all kinds, including flange rail, etc.).
Sub-class 15- 3 Planking (all kinds)
Sub-class 15- 4 Walks (all kinds)
Sub-class 15- 5 Culverts
Sub-class 15- 6 Sewer Systems
Sub-class 15- 7 Signs
Sub-class 15- 8 Crossing Gates, Bells and Signals
Sub-class 15- 9 Grading
Sub-class 15-10 Fences
Sub-class 15-11 Highway Bridges—Timber
Sub-class 15-12 Highway Bridges—Timber and Steel
Sub-class 15-13 Highway Bridges—Masonry (including masonry and steel)
Sub-class 15-14 Foot Bridges—Timber
Sub-class 15-15 Foot Bridges—Timber and Steel
Sub-class 15-16 Concrete Pile and Pier Trestles (railway)
Sub-class 15-17 Buildings (all kinds)
Sub-class 15-18 Outside Electric Lighting

Account 16—Station and Office Buildings

Sub-class 16- 1 Individual Items
Sub-class 16- 2 Grading Grounds
Sub-class 16- 3 Buildings—Light Frame ($1,000 or less)
Sub-class 16- 4 Buildings—Frame (over $1,000—including stucco)
Sub-class 16- 5 Buildings—Brick (including stucco)
Sub-class 16- 6 Buildings—Structural Steel, Concrete and Brick
Sub-class 16- 7 Station Platform Canopies
Sub-class 16- 8 Platforms and Steps—Brick and Concrete
Sub-class 16- 9 Platforms and Steps—Timber
Sub-class 16-10 Platforms and Steps—Filled—(including curb)
Sub-class 16-11 Outside Electric Lighting
Sub-class 16-12 Icing Facilities
Sub-class 16-13 Walks
Sub-class 16-14 Stock Pens and Scales
Sub-class 16-15 Paving (all kinds, incl. sewer systems in connection therewith)
Sub-class 16-16 Track Scales
Sub-class 16-17 Wagon and Foot Bridges
Sub-class 16-18 Freight Handling Derricks—Fixed
Sub-class 16-19 Machinery and Apparatus
Sub-class 16-20 Mechanical Humps—Steel and Concrete

Note—Appurtenances such as furniture, heating facilities and lighting within buildings, outbuildings, wells, walks, fences, water, sanitary sewers, and heating lines, mail cranes, landscaping, etc., should be included with the building to which they pertain.

Account 17—Roadway Buildings

Sub-class 17- 1	Individual Items
Sub-class 17- 2	Grading Grounds
Sub-class 17- 3	Buildings—Light Frame ($1,000 or less)
Sub-class 17- 4	Buildings—Frame (over $1,000, including stucco)
Sub-class 17- 5	Buildings—Brick (including stucco)
Sub-class 17- 6	Buildings—Structural Steel, Concrete and Brick
Sub-class 17- 7	Platforms and Steps—Filled
Sub-class 17- 8	Platforms and Steps—Timber
Sub-class 17- 9	Platforms and Steps—Concrete and Brick
Sub-class 17-10	Tanks—Metal
Sub-class 17-11	Machinery

Account 18—Water Stations

Sub-class 18- 1	Individual Items
Sub-class 18- 2	Grading Grounds
Sub-class 18- 3	Buildings—Light Frame ($1,000 or less)
Sub-class 18- 4	Buildings—Frame (over $1,000, including stucco)
Sub-class 18- 5	Buildings—Brick (including stucco)
Sub-class 18- 6	Buildings—Structural Steel, Concrete and Brick
Sub-class 18- 7	Machinery and Apparatus
Sub-class 18- 8	Water Tanks—Wood—Untreated
Sub-class 18- 9	Water Tanks—Wood—Treated
Sub-class 18-10	Water Tanks—Metal
Sub-class 18-11	Wells
Sub-class 18-12	Sumps
Sub-class 18-13	Penstocks (complete, including pit and drainage)
Sub-class 18-14	Reservoirs (complete, including drainage and spillways)
Sub-class 18-15	Water Treating Plants—Complete
Sub-class 18-16	Outside Pipe Lines

Account 19—Fuel Stations

Sub-class 19- 1	Individual Items
Sub-class 19- 2	Mechanical Coaling Stations—Wood
Sub-class 19- 3	Mechanical Coaling Stations—Concrete and Steel
Sub-class 19- 4	Wood Trestle Type with incline
Sub-class 19- 5	Platforms, etc. (outlying facilities)

Account 20—Shops and Enginehouses

Sub-class 20- 1	Individual Items
Sub-class 20- 2	Grading Grounds
Sub-class 20- 3	Buildings—Light Frame ($1,000 or less)
Sub-class 20- 4	Buildings—Frame (over $1,000, including stucco)
Sub-class 20- 5	Buildings—Structural Steel—Concrete and Brick
Sub-class 20- 6	Buildings—Brick (including stucco)
Sub-class 20- 7	Stacks—Steel
Sub-class 20- 8	Stacks—Brick and Concrete
Sub-class 20- 9	Platforms and Steps—Filled
Sub-class 20-10	Platforms and Steps—Timber
Sub-class 20-11	Platforms and Steps—Concrete and Brick
Sub-class 20-12	Outside Electric Lighting
Sub-class 20-13	Outside Pipe Lines
Sub-class 20-14	Paving

Sub-class 20-15	Fences
Sub-class 20-16	Turntables (complete, including pit, etc.).
Sub-class 20-17	Transfer Tables (complete, including pit, etc.).
Sub-class 20-18	Pits—Timber
Sub-class 20-19	Pits—Masonry and Steel
Sub-class 20-20	Foot Bridges—Timber and Steel
Sub-class 20-21	Freight Handling Derricks—Fixed
Sub-class 20-22	Cinder Conveyors
Sub-class 20-23	Metal Storage Tanks
Sub-class 20-24	Wheel and Dolly Tracks
Sub-class 20-25	Sewer Systems
Sub-class 20-26	Walks

Account 21—Grain Elevators

Sub-class 21- 1	Individual Items

Account 22—Storage Warehouses

Sub-class 22- 1	Individual Items
Sub-class 22- 2	Buildings—Frame
Sub-class 22- 3	Buildings—Light Frame
Sub-class 22- 4	Buildings—Brick
Sub-class 22- 5	Metal Storage Tanks

Account 23—Wharves and Docks

Sub-class 23- 1	Individual Items
Sub-class 23- 2	Buildings—Light Frame ($1,000 or less)
Sub-class 23- 3	Buildings—Frame (over $1,000, including stucco)
Sub-class 23- 4	Open Deck Trestle—Untreated
Sub-class 23- 5	Cradles—Timber
Sub-class 23- 6	Cluster Piling
Sub-class 23- 7	Shore Protection Piling
Sub-class 23- 8	Rip Rap
Sub-class 23- 9	Grading
Sub-class 23-10	Dredging
Sub-class 23-11	Paving

Account 24—Coal and Ore Wharves

Sub-class 24- 1	Individual Items

Account 26—Telegraph and Telephone Lines

Sub-class 26- 1	Individual Items
Sub-class 26- 2	Telephone Exchange
Sub-class 26- 3	Office Apparatus
Sub-class 26- 4	Line Wire—Copper
Sub-class 26- 5	Line Wire—Iron
Sub-class 26- 6	Poles
Sub-class 26- 7	Cross Arms
Sub-class 26- 8	Underground Conduits
Sub-class 26- 9	Buildings—Light Frame ($1,000 or less)
Sub-class 26-10	Buildings—Frame (over $1,000, including stucco)
Sub-class 26-11	Buildings—Structural Steel, Concrete and Brick

Account 27—Signals and Interlockers

Sub-class 27- 1 Individual Items
Sub-class 27- 2 Buildings—Light Frame ($1,000 or less)
Sub-class 27- 3 Buildings—Frame (over $1,000, including stucco)
Sub-class 27- 4 Buildings—Brick (including stucco)
Sub-class 27- 5 Interlocking Towers—Frame
Sub-class 27- 6 Interlocking Plants
Sub-class 27- 7 Manual Signals
Sub-class 27- 8 Automatic Block Signal Systems
Sub-class 27- 9 Automatic Color Light Signal Systems
Sub-class 27-10 Automatic Train Control Systems

Account 29—Power Plant Buildings

Sub-class 29- 1 Individual Items
Sub-class 29- 2 Buildings—Light Frame ($1,000 or less)
Sub-class 29- 3 Buildings—Frame (over $1,000, including stucco)
Sub-class 29- 4 Buildings—Brick (including stucco)
Sub-class 29- 5 Buildings—Structural Steel, Concrete and Brick
Sub-class 29- 6 Stacks—Steel
Sub-class 29- 7 Stacks—Brick and Concrete
Sub-class 29- 8 Grading Grounds

Account 30—Power Sub-Station Buildings

Sub-class 30- 1 Individual Items
Sub-class 30- 2 Buildings—Light Frame ($1,000 or less)
Sub-class 30- 3 Buildings—Frame (over $1,000, including stucco)
Sub-class 30- 4 Buildings—Brick (including stucco)
Sub-class 30- 5 Buildings—Structural Steel, Concrete and Brick

Account 31—Power Transmission Systems

Sub-class 31- 1 Individual Items
Sub-class 31- 2 Outside Electric Lines—Complete

Account 32—Power Distribution Systems

Sub-class 32- 1 Individual Items
Sub-class 32- 2 Steam Lines
Sub-class 32- 3 Outside Electric Lines—Complete
Sub-class 32- 4 Air Lines
Sub-class 32- 5 Tie Stations—C.T.I. (including buildings and equipment)
Sub-class 32- 6 Rail Bonding—C.T.I.
Sub-class 32- 7 Distribution Lines—A.C.—C.T.I.
Sub-class 32- 8 Catenary Lines, complete—D.C.—C.T.I.
Sub-class 32- 9 Outside Supervisory Control System—C.T.I.

Account 33—Power Line Poles and Fixtures

Sub-class 33- 1 Individual Items
Sub-class 33- 2 Pole Lines—Wood
Sub-class 33- 3 Catenary—Steel Structures—C.T.I.
Sub-class 33- 4 Pole Lines—Metal

Account 34—Underground Conduits

Sub-class 34- 1 Individual Items
Sub-class 34- 2 Underground Conduits

Account 35—Miscellaneous Structures

Sub-class 35- 1 Individual Items
Sub-class 35- 2 Buildings—Light Frame ($1,000 or less)
Sub-class 35- 3 Buildings—Frame (over $1,000, including stucco)
Sub-class 35- 4 Buildings—Structural Steel, Concrete and Brick
Sub-class 35- 5 Outside Electric Lighting
Sub-class 35- 6 Telpher Systems

Account 36—Paving

Sub-class 36- 1 Individual Items
Sub-class 36- 2 Paving (all kinds)

Account 37—Roadway Machines

Sub-class 37- 1 Individual Items
Sub-class 37- 2 Section Inspection Motor Cars
Sub-class 37- 3 Hand Cars
Sub-class 37- 4 Push Cars
Sub-class 37- 5 Pile Drivers
Sub-class 37- 6 Rail Unloaders
Sub-class 37- 7 Tamping Machines
Sub-class 37- 8 Ballast Plows
Sub-class 37- 9 Rail Laying Machines
Sub-class 37-10 Small Tools

Account 38—Roadway Small Tools

Non-Depreciable

Account 39—Assessments for Public Improvements

Non-Depreciable

Account 40—Revenues and Operating Expenses During Construction

Non-Depreciable

Account 41—Cost of Road Purchased

Non-Depreciable

Account 42—Reconstruction of Road Purchased

Non-Depreciable

Account 43—Other Expenditures—Road

Non-Depreciable

Account 44—Shop Machinery

Sub-class 44- 1 Individual Items
Sub-class 44- 2 Air Compressors
Sub-class 44- 3 Boilers (including settings and metal chimneys)
Sub-class 44- 4 Traveling Cranes
Sub-class 44- 5 Steam Hammers
Sub-class 44- 6 Boiler Washout Systems
Sub-class 44- 7 Stationary Engines
Sub-class 44- 8 Shop Mules, Tractors and Push Cars
Sub-class 44- 9 Shop Machinery
Sub-class 44-10 Shafting
Sub-class 44-11 Belting
Sub-class 44-12 Shop Tools

Account 45—Power Plant Machinery

Sub-class 45- 1 Individual Items
Sub-class 45- 2 Electric Power Plant Apparatus
Sub-class 45- 3 Boilers (including settings and metal chimneys)
Sub-class 45- 4 Stationary Engines
Sub-class 45- 5 Other Machinery and Apparatus

Account 46—Power Substation Apparatus

Sub-class 46- 1 Individual Items
Sub-class 46- 2 Electric Power Plant Apparatus
Sub-class 46- 3 Other Machinery and Apparatus

Account 47—Unapplied Construction Material and Supplies

Non-Depreciable

Account 51—Steam Locomotives

Sub-class 51- 1 All

Account 53—Freight Train Cars

Sub-class 53- 1 Wood
Sub-class 53- 2 Composite
Sub-class 53- 3 Steel

Account 54—Passenger Train Cars

Sub-class 54- 1 Wood
Sub-class 54- 2 Steel

Account 56—Floating Equipment

Sub-class 56- 1 Steamers
Sub-class 56- 2 Steam Tugs and Scows
Sub-class 56- 3 Miscellaneous
Sub-class 56- 4 Landing Barges

Account 57—Work Equipment

Sub-class 57- 1 Shop Locomotives—Steel
Sub-class 57- 2 Miscellaneous Cars
Sub-class 57- 3 Pile Drivers—Wood
Sub-class 57- 4 Pile Drivers and Derricks—Steel
Sub-class 57- 5 Wrecking Cranes—Steel
Sub-class 57- 6 Wrecking Cranes—Wood
Sub-class 57- 7 Other Work Equipment—Wood
Sub-class 57- 8 Other Work Equipment—Steel

Account 58—Miscellaneous Equipment

Sub-class 58- 1 Automobiles
Sub-class 58- 2 Trucks
Sub-class 58- 3 Trailers
Sub-class 58- 4 Chassis

Accounts 71 to 75, and 77—General Expenditures

Non-Depreciable

Account 76—Interest During Construction

Non-Depreciable

NOTE—In setting up amounts under the above sub-classes, the names of the classes should be shown exactly as written, in order to insure uniformity throughout the setting up of the Depreciation Base. Phrases in parentheses are shown for information only and are not to be included as a part of the sub-class name.

Appendix F

(6) STUDY STATISTICAL REQUIREMENTS OF THE ACCOUNTING, OPERATING OR OTHER DEPARTMENTS WITH RESPECT TO MAINTENANCE OF WAY AND STRUCTURES, AND RECOMMEND REPORTS FOR MAINTENANCE FOREMEN WHICH AS FAR AS POSSIBLE WILL REDUCE THE NUMBER REQUIRED AND PERMIT UNIFORMITY, SIMPLICITY AND ECONOMY

E. S. Butler, Chairman, Sub-Committee; E. B. Crane, T. H. Greene, W. E. Heimerdinger, W. A. Hill, Henry Lehn, W. T. Mead, C. Oberdorf, V. R. Walling.

This assignment has been taken as the continuation of a series of reports previously presented, with the idea that when progress reports are completed, all the data gathered may be arranged and presented as a final report. There may be considered as already presented, the following reports:

Proceedings—Vol. 27—Pages 277-278:
Outline of Typical Reporting System in M. of W. Department.
Proceedings—Vol. 26—Pages 843-858:
Design of Foreman's daily time report.
Proceedings—Vol. 27—Pages 279-284:
Design of labor Recapitulation and Distribution sheet.

This year the Committee has undertaken a study of Daily Material Report for use of Section Foremen and other Track Foremen.

CURRENT PRACTICE ON TYPICAL RAILROADS

For the purpose of finding out the practice on representative railroads, copies of material report forms were obtained from sixteen railroads, seven of which use a daily report. One of those using a monthly report is considering the advisability of changing to a daily report, and one of the railroads has only recently changed from a daily to a monthly report. Two of the roads that use monthly reports furnish a small book to the section foreman in which he is required to enter daily a record of the material received, used, recovered and shipped. This memorandum book becomes a permanent record of the section.

One road which uses a monthly report requires the foreman also to make a daily report on a post card of labor and material used. The purpose of this post card report is to keep the roadmaster advised daily of the rate of expenditures on his division.

On two roads the same daily report form is used by bridge and building, signal and other foremen.

The size of the forms used by the seven roads requiring a daily material report vary from 7 in. by 8 in. printed on one side, to 11 in. by 17 in. printed on both sides.

The following tabulation shows the data provided for on the daily report forms which were submitted to the Sub-Committee.

Data Provided for on Form	*A*	*B*	*C*	*D*	*E*	*F*	*G*
			Designation of Railroad				
1. Material Used							
Location	x	x	x	x	x	x	x
Description	x	x	x	x	x	x	x
Quantity	x	x	x	x	x	x	x
Main Track	x	x	x	x	..	x	x
Side Track	x	x	x	x	..	x	x
Other Companies	x	x	x	..	x	..	x
New Tracks	x	x	x	..	x	..	..
New	x	x	x	x	x	x	x
Second Hand	x	x	x	x	x	x	x
Scrap	x	..	..	..	..	..	..
2. Material Released							
Location	x	x	x	x	x	x	x
Description	x	x	x	x	x	x	x
Quantity	x	x	x	x	x	x	x
Main Track	x	x	x	x	..	x	x
Side Track	x	x	x	x	..	x	x
Abandoned Track	x	x	x	..	x	..	..
Other Companies	x	x	x	..	x	..	x
Usable	x	..	..	x	x	x	x
Scrap	x	..	..	x	x	x	x
3. Material Received							
Description	..	x	x	x	x	x	..
Unit	..	x	x	x	x	x	..
Quantity	..	x	x	x	x	x	..
Received from	..	x	x	x	x	x	..
Car Initial	..	x	x	..	x	x	..
Car Number	..	x	x	..	x	x	..
New	..	x	x	x	..	x	..
Second Hand	..	x	x	x	..	x	..
Remarks	..	..	..	..	..	x	..
4. Material Shipped							
Description	..	x	x	x	x	x	..
Unit	..	x	x	x	x	x	..
Quantity	..	x	x	x	x	x	..
Car Initial	..	x	x	..	x	x	..
Car Number	..	x	x	..	x	x	..
Shipped to	..	x	x	x	x	x	..
New	..	x	x	x	..	x	..
Second Hand	..	x	x	x	..	x	..
Scrap	..	..	..	x	..	x	..
Remarks	..	..	..	..	..	x	..
5. Ties Used in Main Track							
Kind	..	..	x	x	..	..	..
Class	..	..	x	..	..	..	..
Mile	..	x	x	x	..	..	..
Designation of Track	..	x	x	x	..	..	..
Number of Ties	..	x	x	x	..	..	..

Data Provided for on Form	*A*	*B*	*C*	*D*	*E*	*F*	*G*
				Designation of Railroad			
6. Ties Used in Side Tracks							
Kind	..	..	..	x	..	..	..
Class	..	..	..	..	..	..	..
Location	..	x	x	x	..	..	..
Name of Siding	..	x	x	x	..	..	..
Number of Cross-Ties	..	x	x	x	..	..	..
Number of Switch Ties	..	x	x	..	..	..	..
Length of Switch Ties	..	x	x	..	..	..	..
7. Cross-Ties Removed from Track							
Untreated	..	..	..	x	..	x	x
Treated	..	..	..	x	..	x	x
Location	..	..	..	x	..	x	x
Main Track	..	..	..	x	..	x	x
Side Track	..	..	..	x	..	x	x
Kind of Wood	..	..	..	..	..	x	x
Tie Plated or not	..	..	..	x	..	x	..
Year Laid	..	..	..	x	..	x	x
Cause of Removal	..	..	..	..	..	..	..
Decayed	..	..	..	x	..	x	x
Rail Cut	..	..	..	x	..	x	x
Split	..	..	..	x	..	x	..
Damaged	..	..	..	x	..	x	x
Burned	..	..	..	..	..	..	x
Broken	..	..	..	..	..	..	x
Other	..	..	..	x	..	x	..

Railroad "A."	Form provides for reporting class of track, as passenger, freight or common.
Railroad "B."	Form also provides for reporting labor and equipment used.
Railroad "E."	Form also provides for reporting work train service and work equipment used.
Railroad "F."	Form also provides for reporting labor, record of tie tamper and motor car operation and general remarks.
Railroad "G."	Material received and material shipped is reported on a different form on day received or shipped.
Railroad "A," "E," "F" and "G."	Forms do not provide a space for reporting ties used separately from other material used.

PROPOSED DAILY MATERIAL REPORT

The foregoing tabulation indicates that the minimum requirements for a Track Foreman's daily material report are:

- Material Used
  - Location
  - Description
  - Quantity
    - New
    - Second hand
- Material released
  - Location
  - Description
  - Quantity

To meet these minimum requirements and to reduce, insofar as possible, the clerical work required of the Foreman and Supervisor (Summarizing to be done in office of Division Engineer or Division Accountant), and to furnish such additional information as the sub-committee thought necessary, the form included herein, marked Exhibit A, has been designed. On this form are included necessary instructions. The form as designed is 8½ in. by 11 in. in size and should be bound in pads of 100 sheets. The form may also be bound in book form with alternate sheets perforated, the perforated sheet to be forwarded each day to the Supervisor and the sheets not perforated retained in book form and, if desired, forwarded at the end of the month, thus combining the advantages of the daily and monthly method of reporting material used.

The tabulation in connection with Current Practice on Typical Railroads will afford a carrier desiring a more elaborate daily report suggestions for the designing of a form to meet its requirements.

Another question to be decided by the individual carrier is the comparative merits of having certain items of material printed on the daily report form as against leaving blank spaces for foremen to write in the items. Relative advantages would appear to depend somewhat on conditions on each separate road. However, it would seem that the use of a form with blank spaces would be more satisfactory as items of material used each day are ordinarily not of sufficient number to seriously burden the foremen in writing them in. Economy of form space is also an argument for use of blank spaces.

There is also the question of combining reports of material and labor. If combined, the daily report assists in detecting failure in reporting materials used or released and requires only one description of work.

Conclusion

The form included herein as Exhibit A is recommended for inclusion in the Manual.

Exhibit "A"

Form No........

THE NORTH & SOUTH RAILROAD COMPANY

........*Northern*.....Division

Sheet *1* of *3* Sheets of this form forwarded this date

Section or Gang Number *4*

June 14 1924

TRACK FOREMAN'S DAILY MATERIAL REPORT

Location *York*

Class of Work *Extend team track 20 ft A.F.E. #262*

Material, Size and Kind	Unit	Quantity			
		Used		Released	
		New	Usable	Usable	Scrap
1	2	3	4	5	6
1. *Ties 6"x8"-8' Creo. Pine*	*each*	*12*			
2. *Rail 85# O.H. Relay*	*foot*		*40*		
3. *Angle bars 24" Oil treated*	*pair*		*2*		
4. *Bolts 7/8" x 4 1/2"*	*each*	*8*			
5. *Nut locks*	"	*8*			
6. *Spikes 9/16" x 5 1/2"*	"	*48*			
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					

Correct *John Smith* Foreman

Approved *T. L. Gerry* Supervisor

This report is to be forwarded to the Supervisor each day. If no material was used, a blank form should be sent stating that no material was used.

A separate report on this form is to be furnished for each class of work, Repairs to Passenger Tracks, Repairs to Freight Tracks, Repairs to Common Tracks, Repairs to I. & C. Tracks, New Work, etc.

Items of material must be fully described as shown on Record of Material on Hand.

Appendix G

(7) OUTLINE OF WORK FOR ENSUING YEAR

J. H. Hande, Chairman, Sub-Committee; J. T. Powers, E. Y. Allen, H. R. Westcott, B. A. Bertenshaw, C. C. Haire, E. S. Butler, G. R. Walsh.

In considering its program of work not only for future periods, but for the current year, it became necessary for this Committee to give particular attention to a factor existing in connection with its work that does not affect the work of other Committees. That factor is, briefly, the contacts which this Committee's assignments have with Orders of the Interstate Commerce Commission, either those issued and in effect, or those in process of hearing and negotiation prior to promulgation.

This Committee, dealing as it does with "Records and Accounts," is obligated to keep the Association informed as to the scope and effect of whatever Orders are issued by the Commission touching upon the Accounting Classifications, Valuation, Depreciation, and allied subjects. Orders of the Commission in these several fields are usually developed in conference with representatives of the railroads, both in informal and formal hearings. Carriers' representatives, to so confer with the Commission's representatives, are designated by the Association of Railway Executives. In the particular fields mentioned, that Association has officially designated the Presidents' Conference Committee to present the Carriers' views regarding Valuation, and the Railway Accounting Officers' Association to represent the railroads in matters connected with the Accounting Classifications and Depreciation.

It is perfectly obvious that this Committee can make no report expressing its independent point of view regarding any orders in process of development, since that would conflict with the work of the Associations officially designated to present the Carriers' views to the Commission. As to such Orders this Committee can only keep the Association informed regarding developments. So far no formal arrangements have been made whereby representatives of your organization may, with any degree of authority, present to the officially designated representatives of the Carriers, any view which it is felt our organization should express.

As to the character of report that this Committee should make relating to Orders of the Commission after they have been made effective. The Classifications and Orders of the Commission have the full force of law, but only to the extent to which they explicitly specify forms and rules, which represent minimum requirements. If in fulfilling these minimum requirements it is apparent that much of value to the Carriers can be obtained by collecting supplementary material or by gathering the required material in subdivisions whereby wider inter-departmental use may be made of such data this Committee takes it to be its duty to recommend such practices as auxiliary to the minimum requirements of the Classification or Order.

There naturally does not appear in the Orders of the Commission any suggestion or recommendation for underlying records or for the methods and organization best adapted to correlate the requirements of the Commission with the needs of the Carriers themselves. That there was a need for such analysis and suggestions has been apparent for some time and Committee XI has undertaken to supply such need.

However, in making suggestions from time to time for inclusion in the Manual of forms, methods and organization best adapted to the work in hand, Committee XI has met the objection that such recommendations should not be included in the Manual but should be given as "information only." With a view to obtaining a clear understanding as to the character of report to be developed by this Committee concerning effective Orders of the Commission, and to see what might be established in the way of a program of closer co-operation between this organization and those Associations officially designated to deal with the Commission, this Committee presented to the Board of Direction a careful review of the situation, and closed that review with the following "conclusions":

> "(1) We acknowledge the jurisdiction of these organizations over the negotiations with the Commission preliminary to the issuance of final orders by that body. We recommend that there be developed between the executives of the Association of Railway Executives and of the American Railway Association, a clear-cut program, both as to method and personnel, whereby the opinions of the various divisions of the latter association may be registered with the subordinate bodies of the Association of Railway Executives in a way that will give us a more authoritative status. The opportunity for closer co-operation should be developed.
>
> "(2) We consider that after classifications and orders of the Commission have been made final, it is our duty to (a) analyze their provisions; (b) to suggest and recommend the most efficient method and organization whereby the mandatory provisions of such classifications or orders may be fulfilled; (c) to recommend forms and procedure involved in preparing underlying forms and records, both mandatory and optional; (d) to recommend the subdivisions or subclassifications into which data for mandatory reports may be divided if, in our opinion, such subdividing will afford a wider use of this material to interested departments of the Carriers, and (e) to recommend such supplementary data as we consider should be gathered in the process of complying with mandatory requirements.
>
> "(3) We consider that our recommendations should bear the endorsement of our organization and appear in our Manual as recommended practice."

The Committee on Outline of Work of the Board of Direction has confirmed and endorsed the second and third conclusions given above, and those conclusions will govern whatever work of this character is to be done by Committee XI in the future. The Committee on Outline of Work recognizes the desirability of closer co-operation expressed in Conclusion (1) above, and has placed the matter before the Board of Direction so that negotiations for such improved co-operative basis may be undertaken.

These matters are placed before you for your information.

REPORT OF COMMITTEE XVII—WOOD PRESERVATION

F. C. Shepherd, *Chairman;*
W. G. Atwood,
R. S. Belcher,
Z. M Briggs,
C. S. Burt,
C. C. Cook,
E. A. Craft,
G. M. Davidson,
H. R. Duncan,
E. B. Fulks,
Andrew Gibson,
W. R. Goodwin,
R. S. Hubley,
C. F. Ford, *Vice-Chairman;*
W. H. Kirkbride,
G. P. MacLaren,
F. D. Mattos,
W. D. Pender,
L. J. Reiser,
Dr. Herman von Schrenk,
O. C. Steinmayer,
G. C. Stephenson,
T. H. Strate,
C. M. Taylor,
J. H. Waterman,
Galen Wood,

Committee.

To the American Railway Engineering Association:

This Committee respectfully presents herewith a report covering the following subjects:

1. Revision of Manual (Appendix A).
2. Report on Definitions used in Wood Preservation (Appendix B).
3. Continue Study and Report Upon Service Test Records for Treated Ties (Appendix C).
4. Continue Study, Investigate and Report on Piling Used for Marine Construction (Appendix D).
5. Continue Study and Report Upon Effect of Preservative Treatment by the Use of:
   (a) Creosote and Petroleum (Appendix E).
   (b) Zinc Chloride and Petroleum (Appendix F).
6. Prepare Specifications for Treatment of Air Seasoned Douglas Fir (Appendix G).
7. Outline of work for ensuing year.

Action Recommended

Your Committee recommends that Appendix A—Revision of Manual, be adopted for inclusion in the Manual; Appendix B—Definitions Used in Wood Preservation; Appendix C—Service Test Records; Appendix D—Marine Piling Investigation; Appendix E—Treatment with Creosote and Petroleum; Appendix F—Treatment with Zinc Chloride and Petroleum and Appendix G—Specifications for Treatment of Air Seasoned Douglas Fir, be accepted as information.

Bulletin 313, January, 1929.

Outline of Work for Ensuing Year

1. Revision of Manual.
2. Report on Definitions Used in Wood Preservation.
3. Continue study and Report Upon Service Test Records for Treated Ties.
4. Continue study, Investigate and Report on Piling Used for Marine Construction.
5. Continue Study and Report Upon Effect of Preservative Treatment by the Use of:

   (a) Creosote and Petroleum.
   (b) Zinc Chloride and Petroleum.

6. Prepare Specifications for Treatment of Air Seasoned Douglas Fir.
7. Investigate and Report on Destruction by Termite and Possible Ways of Preventing Same.
8. Investigate Loss of Preservative in Treated Ties in Track Due to Repeated Use of Oil Burning Weed Destroyers.
9. Outline of work for ensuing year.

Respectfully submitted,

THE COMMITTEE ON WOOD PRESERVATION,

F. C. SHEPHERD, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

Dr. Hermann von Schrenk, Chairman, Sub-Committee; R. S. Belcher, C. S. Burt, E. B. Fulks, W. R. Goodwin, F. D. Mattos, O. C. Steinmayer, G. C. Stephenson, Galen Wood.

The Committee has only one revision to offer and this deals with an improved form of shield used in the analysis of creosote. This matter has been the subject of a thorough investigation of a joint committee and a new type has been devised. It is much more convenient than the old type, but in no way affects the results of the analysis. It already has been adopted by the American Wood Preservers' Association and the American Society for Testing Materials. The suggested revision of the Manual is as follows:

Eliminate paragraph (c) at the bottom of page 110, top of page 111, Bulletin 288, Supplement to the Manual, and substitute the following:

> "A galvanized-iron shield lined with one-eighth-inch asbestos of the form and dimensions shown in Fig. 10 shall be used to protect the flask from air currents and to prevent radiation. The cover (top) shall be of transite board made in two parts, or it may be of galvanized iron lined with one-eighth-inch asbestos."

Also substitute the accompanying drawing of the shield for the drawing shown as Fig. 10, page 111, and substitute the accompanying drawing of the apparatus assembly for Fig. 11, page 113.

Conclusions

It is recommended that this revision of the Manual be approved by the Association, and that the subject be continued.

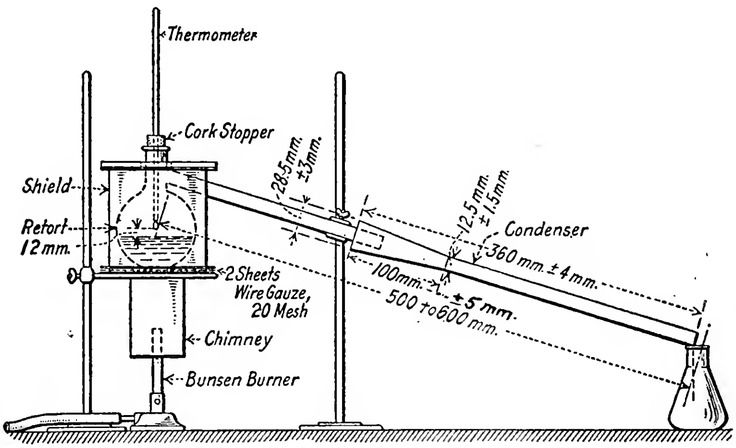
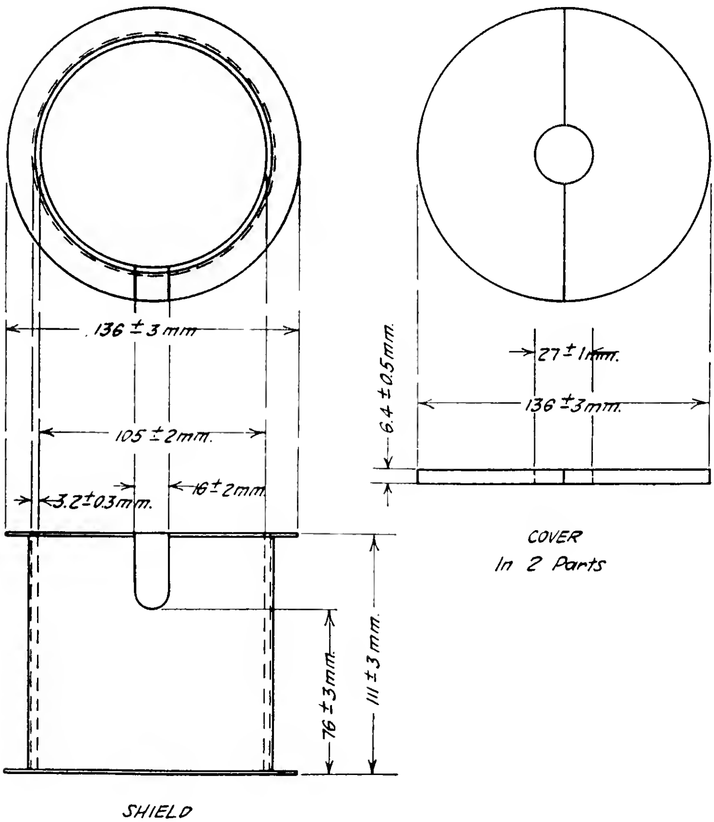


Fig. 1



Flanged Open-End Cylinder
Made of 22 gage Galvanized Iron
with 1/8" Asbestos Lining Riveted to Metal

Fig. 2

SCALE 8 in = 1 ft

Appendix B

(2) REPORT ON DEFINITIONS USED IN WOOD PRESERVATION

E. B. Fulks, Chairman, Sub-Committee; Z. M. Briggs, G. M. Davidson, R. S. Hubley, Dr. von Schrenk, O. C. Steinmayer, G. C. Stephenson and Galen Wood.

Last year the Committee presented a list of definitions of the more important terms used in Wood Preservation. This year the Committee has prepared an additional list of definitions which, when combined with the list previously submitted, includes practically all the terms ordinarily used in Wood Preservation. This work has been carried on by correspondence and a list of definitions is submitted.

DEFINITIONS

Absorption.—Amount of preservative taken up by, or forced into, timber during treatment.

Absorption, Volumetric.—Ratio of the volume of preservative solution absorbed to the total volume of the timber.

Air, Preliminary.—Compressed air forced into wood before, and held during, the injection of preservative.

Allerdyce Process.—A two movement treating process involving the injection of a solution of zinc chloride followed by creosote. (Proposed by R. L. Allerdyce.)

Annual Ring.—In the case of wood, is the growth layer put on in a single growth year.

Anthracene.—A crystalline salt derived from coal tar. Melting point 216.5 degrees C. Boiling point 360 degrees C.

Anthracene Oil.—A distillate from coal tar, distilling between 270 degrees and 400 degrees C. Sometimes called "green oil."

Bacteria (Plural of Bacterium).—The smallest known living organisms, of very simple construction and without chlorophyl. They are parasitic or saprophytic.

Bethell Process.—Pressure treatment with creosote consisting of the following steps: Preliminary vacuum; injection of creosote; final vacuum. Invented by John Bethell in 1838. Now generally known as the "full cell" process.

Bleeding.—The exuding of preservative from treated timber.

Borers, Marine.—Small marine animals which have their homes in burrows or galleries which they excavate in wood submerged in sea water; principally *Teredo, Xylotria, Limnoria* and *Sphaeroma.* Ship worms.

Boulton Process.—Process for removing moisture from wood by boiling it in creosote under a vacuum. (Invented by S. B. Boulton in 1879.)

Brush Treatment.—See Treatment, Brush.

Burnett Process.—Treating wood with a solution of zinc chloride. (Patented by William Burnett in 1838.)

BURNETTIZE.—See Burnett Process.

BUTT TREATMENT.—See Treatment, Butt.

CARBON, FREE.—See Free Carbon.

CARD PROCESS.—Pressure treatment with a mixture of oil and a water solution of a salt, usually creosote and zinc chloride, the mixture being kept uniform by means of a rotary pump. (Patented by J. B. Card in 1906.)

COEFFICIENT OF EXPANSION.—See Expansion Factor.

COKE RESIDUE.—See Residue, Coke.

COKE, TEST.—See Test, Coke.

COPPER SULPHATE.—A salt formed by the action of sulphuric acid upon copper. Used to some extent as a wood preservative.

CORROSIVE SUBLIMATE.—Mercuric Chloride.

CREOSOTE, DISTILLATE.—Same as Creosote.

DATING NAIL.—See Nail, Dating.

DECAY.—Distintegration of the wood substance due to the action of wood destroying fungi. Dote; rot.

DECAY, INCIPIENT.—The early stage of decay which has not proceeded far enough to soften or otherwise perceptibly impair the hardness of the wood.

DISPLACEMENT.—In wood preserving, the volume of wood in a charge as determined by measuring the volume of liquid displaced by the wood in the cylinder.

DISTILLATION TEST.—See Test, Distillation.

DISTILLATE CREOSOTE.—See Creosote, Distillate.

DISTILLATE, OIL.—See Creosote, Distillate.

DISTILLING FLASK.—See Flask, Distilling.

DISTILLING TEST.—See Test, Distilling.

DURABILITY.—The length of time that timber remains sound in service.

EXTRACTION FLASK.—See Flask, Extraction.

FIBER SATURATION POINT.—In wood, the condition in which the cell cavities are empty but the cell walls are fully saturated with water.

FINAL RETENTION.—See Retention, Final.

FLASK, DISTILLING.—Glass flask with a side neck, used in making the distillation test.

FLASK, EXTRACTION.—Glass vessel for containing the solvent in making the test to determine the "Insoluble in Benzol."

FLOAT TEST.—See Test, Float.

FREE CARBON.—Term frequently and improperly used instead of "Matter Insoluble in Benzol."

FUNGUS.—A low form of plant life without root, stem or leaves. Fungi contain no chlorophyl and derive nourishment from organic matter.

GRAVITY.—See Specific Gravity.

GROUPING.—Segregating various woods into classes according to the manner in which they take treatment.

HUMIDITY.—Moisture in the air.

HUMIDITY, RELATIVE.—The amount of moisture in the air expressed as a percentage of the maximum amount that the air could hold at the same temperature and pressure.

Hydrometer.—An instrument used for determining the specific gravity of liquids.

Hygrometer.—An instrument used for measuring the amount of moisture in the air.

Hygroscopic Moisture.—See Moisture, Hygroscopic.

Impervious.—Completely resisting the entrance of liquids. Impenetrable.

Incipient Decay.—See Decay, Incipient.

Initial Air.—Same as Air, Preliminary.

Kick-Back.—Amount of preservative forced out of the cylinder when the pressure is released.

Kiln-Dried.—Wood from which the moisture has been removed in kilns by means of hot air.

Kyanize.—Treating wood by steeping in a solution of mercuric chloride. Invented by John H. Kyan in 1832.

Leach.—To dissolve out by percolation. Refers particularly to the removal of soluble preservatives from wood in contact with wet soil or water.

Lowry Process.—An empty cell process for treating wood with creosote in which there is injected, without a preliminary vacuum, an amount of creosote in excess of the required final retention, this excess then being removed by a quick high vacuum. (Invented by C. B. Lowry in 1906.)

Marine Borers.—See Borers, Marine.

Mercuric Chloride.—A compound of mercury and chlorine; bichloride of mercury; corrosive sublimate.

Moisture Content.—Amount of moisture in wood, usually expressed as percentage of the dry weight of wood.

Moisture, Hygroscopic.—In wood, water which is absorbed by the cell walls as distinguished from "free water" in the cell cavities.

Mold (Mould).—Any of the lower fungi. In general these fungi form loose wefted mycelium on the surface of organic material which frequently becomes covered by a powdery mass of spores.

Mycelium.—The mass of thread-like elements forming the vegetative portion of a fungus.

Nail, Dating.—A nail, having a date or symbol on its head, which is driven into timber to indicate the year in which it was treated or put into service.

Napthalene.—A crystalline salt derived from coal tar. Melting point 79 degrees C. Boiling point 218 degrees C.

Non-Pressure Treatment.—See Treatment, Non-Pressure.

Oil, Water Free.—Oil containing no water; dry oil.

Oil, Wet.—Oil containing more water than allowed by specifications.

Open Tank Treatment.—See Treatment, Open Tank.

Permeability.—The degree to which wood permits the injection of preservatives.

Plug, Tie.—Wooden Plugs used for filling old spike holes; usually creosoted.

Preliminary Air.—See Air, Preliminary.

Preliminary Vacuum.—See Vacuum, Preliminary.

Pressure Period.—That portion of a treating operation during which the preservative is under pressure.

PRESSURE TREATMENT.—See Treatment, Pressure.

PYKNOMETER.—A calibrated bottle used for measuring the volume and weight of a liquid in determining its specific gravity.

REFRACTORY.—Offering resistance to the entrance of preservatives; difficult to treat.

RELATIVE HUMIDITY.—See Humidity, Relative.

RESIDUE.—That portion of an oil or tar which remains in the flask on completion of the distillation test.

RESIDUE, COKE.—The material remaining in the crucible on completion of the coke test.

RETENTION, FINAL.—Same as Net Absorption. See Absorption, Net.

RETENTION, NET.—Net Absorption. See Absorption, Net.

RUEPING PROCESS.—An empty cell process for treating with creosote in which the following sequence is employed: Compressed air; cylinder filled without reducing pressure; pressure held until required absorption is obtained; final vacuum. (Patented by Max Rueping in 1902.)

SAP STAIN.—Discoloration of sapwood by certain fungi which live upon the materials in the sapwood cells. Does not seriously impair the strength of timber.

SHIP WORM.—See Borers, Marine.

SODIUM FLUORIDE.—Sodium Salt of Hydrofluoric Acid.

SOLUTION.—A liquid combination of liquid and non-liquid substance or of two or more liquids, as a salt and water or coal tar and creosote.

SPECIFIC GRAVITY.—The ratio of the weight of a substance to the weight of an equal volume of water under the same conditions.

SPORES.—The reproductive bodies of fungi corresponding to the seeds of higher orders of plants.

SPRAY TREATMENT.—See Treatment, Spray.

SPRINGWOOD.—The inner, usually softer and more porous portion of each annual ring.

SUMMERWOOD.—The outer, usually harder and less porous portion of each annual ring.

SURFACE TREATMENT.—See Treatment, Surface.

TAR ACIDS.—Compounds of carbon, hydrogen and oxygen found in various tars, intermediate in character between acids and alcohols. Those most common in coal tar are carbolic acid and cresylic acid.

TEST, COKE.—A test used to determine the amount of fixed carbon in bituminous materials.

TEST, DISTILLATION.—A test used to determine the proportion of oils and tars which distill between certain temperatures.

TEST, FLOAT.—A test used to determine the viscosity of bituminous materials, applied to creosote coal tar solution as giving an indication of the proportion of tar in solution.

TIE PLUG.—See Plug, Tie.

TIE, TREATED.—Tie to which a preservative has been applied.

TREAT (verb).—To apply preservative to wood.

TREATING PRESSURE.—Amount of pressure used in injecting the preservative into wood, usually expressed as pounds per square inch.

TREATMENT.—Act or manner of treating; also the quantity of preservative specified or used, as "ten-pound treatment."

TREATMENT, BRUSH.—Application of one or more coats of a liquid preservative to the surface of timber with a brush.

TREATMENT, BUTT.—Preservative treatment applied to the lower, or butt end of posts and poles; usually by the open tank process or by brushing.

TREATMENT, NON-PRESSURE.—Process in which the preservative is applied to wood without pressure.

TREATMENT, OPEN-TANK.—Process in which the timber is immersed in hot oil, for various lengths of time, and then immediately in cold oil. Also called "Hot and Cold Bath Treatment."

TREATMENT, PRESSURE.—Process in which pressure is applied to force preservatives into wood.

VACUUM, PRELIMINARY.—Vacuum applied to wood before injecting the preservative in pressure treatment.

VISCOSIMETER.—An instrument used to measure the viscosity of liquids.

VISCOSITY.—The resistance of a liquid to free flow.

VOLUMETRIC, ABSORPTION.—See Absorption, Volumetric.

WATER-FREE OIL.—See Oil, Water-Free.

WELLHOUSE PROCESS.—A pressure Process in which wood is treated with a water solution of zinc chloride and glue followed by a solution of tannin. (Patented by Wm. Wellhouse in 1879.) Also called Zinc-Tannin Process.

WET OIL.—See Oil, Wet.

WOOD PRESERVATION.—The art of protecting timber against the action of destructive agents. Usually refers to the treatment of wood with materials which prevent the attack of fungi, termites, marine borers, etc.

ZINC CHLORIDE.—Salt formed by the action of hydrochloric acid upon zinc. Extensively used as a wood preservative.

ZINC-TANNIN PROCESS.—See Wellhouse Process.

ZONE RATIO.—Ratio of the volume of a zone to the entire volume of the liquid being sampled.

ZONE SAMPLE.—A sample taken from any desired depth or zone in a tank or, more particularly, a tank car.

ZONE SAMPLER.—An instrument for taking zone samples.

Conclusions

It is recommended that this report be accepted as information and the subject be continued.

Appendix C

(3) REPORT UPON SERVICE TEST RECORDS FOR TREATED TIES

Z. M. Briggs, Chairman, Sub-Committee; C. S. Burt, G. M. Davidson, Andrew Gibson, W. R. Goodwin, R. S. Hubley, G. P. MacLaren, T. H. Strate and J. H. Waterman.

(1) The table of tie renewals per mile on various railroads has been brought up to include renewals in 1927. The diagram shows a comparison of annual renewals, five-year average, and cumulative average.

(2) Additional records from the Forest Products Laboratory are published, supplementing the complete table printed in the 1926 Proceedings.

(3) We presented in 1925 a full report of the Fence Post Test on the Atchison, Topeka & Santa Fe Railway at Cleveland, Texas. Some posts were added to this test in 1926, and an inspection was made in October, 1927, the results of which are shown in a summary. These records indicate the value of pressure treatment as compared with brush and open-tank treatments, and the value of standard preservatives compared with various experimental and proprietary solutions.

(4) Reports are submitted covering special test tracks on the Baltimore & Ohio, Chicago, Burlington & Quincy, Illinois Central, and Northern Pacific.

Chicago, Burlington & Quincy Railroad

Test tracks of 1000 ties each were started in 1909 on 20 divisions, comprising all kinds of wood used for ties. About 25,000 ties were laid in continuous sections, of which 3264 were untreated; 3258 were treated with creosote, full cell process; 15,852 were treated with zinc and creosote, Card process; and 2495 were treated with zinc chloride, Burnett process. The average life of the untreated ties was as follows:

Average Life of Untreated Ties (in Years)

Cottonwood	3.1	Red Gum	4.0	Poplar	5.0	Hickory	5.2
Sycamore	3.2	Hard Maple	4.4	Tamarack	5.1	Pin Oak	6.0
Tupelo Gum	3.3	Beech	4.7	Elm	5.1	Chestnut	6.1
Soft Maple	3.6	Hemlock	4.8	Ash	5.1	Cypress	6.5
Birch	3.6	Loblolly Pine	4.9	Red Oak	5.2	White Oak	8.5

Percentages removed to October, 1927, are as follows:

Process	*Placed*	*Removed*	
Creosote	3,258	830	25%
Card	15,852	8,473	53%
Burnett	2,495	1,770	71%
Untreated	3,264	3,225	99%

The test indicates the superiority of treated ties over untreated ties, of the Card process over plain zinc chloride, and of creosote over both. The creosoted ties were treated with 10 to 12 lb. of creosote per cu. ft.; no empty-cell creosoted ties were included in the test.

SPECIAL TEST TRACKS - BALTIMORE & OHIO RAILROAD
SUMMARY AFTER 1927 INSPECTION

Wood	Treatment	Location	Year Put in	* Number in test	Number Removed to date	Per cent removed	Estimated average life years
Red Oak	Untreated	Herring Run, Md.	1914	298	298	100.0	5.4
Red Oak	0.35-lb. Zinc Chloride	Herring Run, Md.	1914	162	131	80.9	11.4
Red Oak	0.63-lb. Zinc Chloride	Herring Run, Md.	1914	211	117	55.4	13.4
Red Oak	4.02-lb. Creosote	Herring Run, Md.	1914	300	94	31.3	15.7
Red Oak	9.78-lb. Creosote	Herring Run, Md.	1914	300	5	1.7	--
Red Oak	5.16-lb. Water Gas Tar Creosote	Herring Run, Md.	1914	150	24	16.0	--
Red Oak	6.12-lb. Water Gas Tar Creosote	Herring Run, Md.	1914	150	23	15.3	--
Red Oak	7.09-lb. Water Gas Tar Creosote	Herring Run, Md.	1914	150	59	39.3	14.9
Red Oak	10.90-lb. Water Gas Tar Creosote	Herring Run, Md.	1914	150	32	21.3	17.0
Red Oak	11.00-lb. Water Gas Tar Creosote	Herring Run, Md.	1914	212	87	41.0	14.7
Red Oak	0.41-lb. Sodium Fluoride	Herring Run, Md.	1914	300	109	36.4	15.2
Red Oak	Card - 0.63# Zn.Cl. - 0.76# Creosote	Herring Run, Md.	1914	300	179	59.7	13.0
Red Oak	Card - 0.59# Zn.Cl. - 0.37# Creosote - 1.35# W.G. Tar	Herring Run, Md.	1914	300	83	27.7	16.2
Red Oak	Card - 0.5# Zn.Cl. - 2.0# Creosote	Herring Run, Md.	1915	288	127	44.1	14.4
White Oak	Untreated	Blanchester, O.	1911	760	731	96.6	10.1
Red Oak	5.7-lb. Creosote	Blanchester, O.	1911	873	34	3.9	19.5
Beech, Maple, etc.	5.7-lb. Creosote	Blanchester, O.	1911	252	85	33.7	17.2
Red Oak	Card - 0.5# Zn. Cl. - 2.0# Creosote	Blanchester, O.	1911	1,125	349	31.1	17.5
Beech, Maple, etc.	Card - 0.5# Zn. Cl. - 2.0# Creosote	Blanchester, O.	1911	1,219	569	46.7	16.2
Red Oak	Timber Asphalt - Open Tank	Blanchester, O.	1911	984	942	95.9	10.6

A. T. & S. F. RY. - CLEVELAND, TEXAS.

RESULTS OF FENCE POST TEST TO OCTOBER, 1927.

No. of Posts	Treatment	Date Set	Date all out	Posts Remaining No.	Condition	Timber
13	0.5% Antinonnin	1913	1920	0		Southern Pine
14	2% Sod. Sil. Fluoride	1913		11	Very badly decayed	Southern Pine
5	0.25% Antinonnin	1913	1926	0		Southern Pine
7	0.25% Antinonnin	1913	1921	0		Southern Pine
13	1% Sod. Sil. Fluoride	1913		13	Badly decayed at ground	Southern Pine
22	5-lbs. Ger. Creosote, Rueping	1913		22	9 slightly soft below ground	Southern Pine
17	34.5# " " Full Cell	1913		17	All O.K.	Southern Pine
15	Painted-Lyster Wood Creosote	1913	1921	0		Southern Pine
3	Painted (2 coats R.I.W.)	1913	1920	0		Southern Pine
11	4.5% Zinc Chloride	1913		11	All O.K.	Southern Pine
13	0.12% Antinonnin	1913	1927	0		Southern Pine
15	Painted Ger. Creosote	1915	1920	0		Southern Pine
15	Untreated	1913	1919	0		Southern Pine
15	Painted Locustine	1913	1920	0		Southern Pine
6	Painted ~~Raves~~ Reeves Wood Pres.	1913		2	Fair	Southern Pine
6	Painted Barrett Creosote	1913	1921	0		Southern Pine
15	Painted Carbolineum	1913	1926	0		Southern Pine
10	2% Zn. Cl. - Open Tank	1913		9	4 good - 4 sl. decay.- 1 decayed	Southern Pine
21	Sucher Process	1922		17	Very good	Southern Pine
25	5# Creosote, Rueping	1922		25	Excellent	Rocky Mtn. Douglas Fir
4	1-lb. Zinc Chloride	1922		4	2 sl.decay.- 2 sound	Rocky Mtn. Douglas Fir
7	1/2-lb. Zinc Chloride	1922		7	4 sl.decay.- 3 sound	Rocky Mtn. Douglas Fir
23	2-1/2-lb. Creosote, Rueping	1922		23	5 sl.decay.-18 sound	Rocky Mtn. Douglas Fir
31	Copper Sulphate	1918		23	3 good - 5 sl. decay.- 15 decayed	Southern Pin
30	Ferrous Chloride	1918		18	All poor. Closed 1926	Red Oak
110	Ferrous Chloride	1918		37	All poor. Closed 1926 (Solution caused separation of wood fibre)	Southern Pine
20	Molten Slphr. Preser. Proc.	1926		20	Excellent	Southern Pine
80	X-Petroleum	1926		80	Excellent	Southern Pine
61	X-Petroleum	1926		61	Excellent	Southern Pine
95	Zinc Oil Emulsion	1926		95	Excellent	Southern Pine
722						

*Omits ties removed account of derailments and installing switches.
Traffic—17,128,000 tons per year at Herring Run; 5,190,000 tons at Blanchester.
Estimated average life at Herring Run from Forest Products Laboratory Curve.
Estimated from inspection of ties at Blanchester.

Record of Completed

Supplementary to the Completed Records Published in the

Species	Dimensions	Form	Preparation	Preservative	Process	No. Ties	Railroad
Birch, yellow.....	....	Hewed	Green	None	Untreated	97	C. & N. W.
Birch, yellow.....	6"x7"x8'	Hewed	Green	None	Untreated	104	C. & N. W.
Birch, yellow.....	6"x7"x8'	Hewed	Green	None	Untreated	100	C. & N. W.
Hemlock.........	6"x7"x8'	Hewed	Seasoned	None	Untreated	98	C. & N. W.
Oak, red.........	6"x7"x8'	Hewed	Green	None	Untreated	100	C. & N. W.
Oak, red.........	6"x7"x8'	Hewed	Green	None	Untreated	100	C. & N. W.
Oak, red.........	....	Hewed	Green	None	Untreated	100	C. & N. W.
Pine, loblolly.....	6"x7"x8'	Hewed	Green	None	Untreated	100	C. & N. W.
Pine, loblolly.....	6"x7"x8'	Hewed	Green	None	Untreated	101	C. & N. W.
Pine, loblolly.....	6"x7"x8'	Hewed	Seasoned	None	Untreated	100	C. & N. W.
Pine, longleaf.....	6"x7"x8'	Hewed	Green	None	Untreated	98	C. & N. W.
Pine, longleaf.....	6"x7"x8'	Hewed	Green	None	Untreated	95	C. & N. W.
Tamarack........	6"x7"x8'	Hewed	Green	None	Untreated	100	C. & N. W.

[1] F. P. L.—Average life computed by Forest Products Laboratory.

Illinois Central System

A test section of cross-ties was established in 1926, located 1.5 miles north of Metropolis, Ill., including all the woods used for ties by this road. One-half of each group were bored and adzed, and one-half not machined. The following numbers of ties were installed out of face, 6 inch by 8 inch by 8 feet 0 inch ties, tie plated, 110-lb. rail, tangent track:

Kind of Wood	*Number* Adzed	*Number* Rough	*Treatment* Distillate
Red Oak	255	252	5.25 lb. per cu. ft. creosote
Cypress	253	255	6.55 lb. per cu. ft. creosote
Pine	250	255	5.25 lb. per cu. ft. creosote
White Oak	259	252	5.25 lb. per cu. ft. creosote
Chestnut	50	50	5.25 lb. per cu. ft. creosote
Beech	50	50	5.25 lb. per cu. ft. creosote
Ash	50	50	5.25 lb. per cu. ft. creosote
Elm	50	50	5.25 lb. per cu. ft. creosote
Sycamore	50	50	5.25 lb. per cu. ft. creosote
Maple	50	48	5.25 lb. per cu. ft. creosote
Black Gum	72	30	5.25 lb. per cu. ft. creosote
Magnolia	51	49	5.25 lb. per cu. ft. creosote
Sweet Gum	50	50	5.25 lb. per cu. ft. creosote
	1,490	1,441	

Service Tests of Ties

1926, 1927 and 1928 A.W.P.A. and A.R.E.A. Proceedings

Location	Date Set	TRACK CONDITION			Year 100% re-moved	AVERAGE LIFE		Cause of Removal
		Tie Plates	Spikes	Ballast				
		Kind	Kind			Years	Reference[1]	
Chadron, Nebraska......	1914	Partly	Cut	Gravel	1926	6.2	F. P. L.	Decay
40th St. Station, Chicago.	1914	None	Cut	Gravel	1923	5.0	F. P. L.	Decay
Verdi, Minnesota.........	1914	None	Cut	Gravel	1926	4.8	F. P. L.	Decay
Chadron, Nebraska......	1914	Sellers	Cut	Gravel	1927	7.2	F. P. L.	Decay
Carroll, Iowa............	1914	Partly	Cut	Gravel	1926	6 5	F. P. L.	Decay
40th St. Station, Chicago.	1914	Sellers	Cut	Gravel	1927	6.1	F. P. L.	Decay
South Norfolk, Nebraska.	1914	Partly	Cut	Gravel	1922	5.8	F. P. L.	Decay
Bark River, Michigan....	1914	None	Cut	Gravel	1927	7.1	F. P. L.	Decay
Carroll, Iowa............	1914	Sellers	Cut	Gravel	1927	6.3	F. P. L.	Decay
Womac Station, Illinois...	1914	Sellers	Cut	Gravel	1927	5.3	F. P. L.	Decay
Chadron, Nebraska......	1914	Sellers	Cut	Gravel	1927	6.0	F. P. L.	Decay
40th St. Station, Chicago.	1914	Sellers	Cut	Gravel	1927	5.7	F. P. L.	92 Decay; 3 mech. wear
Carroll, Iowa............	1914	Sellers	Cut	Gravel	1927	7.2	F. P. L.	Decay

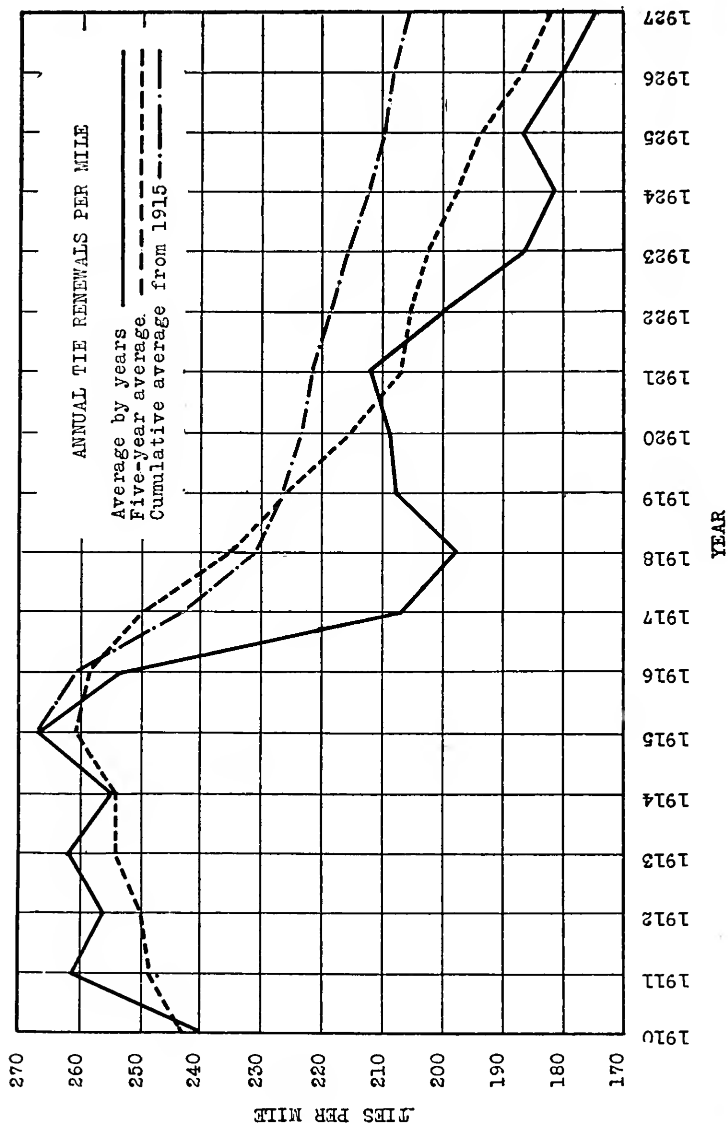
Special Test Tracks—Northern Pacific Railway

(1) St. Paul Division—milepost 89 to 103½, Gregory to Rice—44,159 hewn Minnesota tamarack ties, treated 1916 with 80-20 per cent creosote coal tar mixture, 6.75 lb. per cu. ft. Only 4 ties had been removed to June, 1928, and it is estimated an average life of 20 years will be secured.

(2) Rocky Mountain Division—Westward main-line track, west of Missoula yard—1637 hewn western hemlock ties, treated with a mixture of 80 per cent No. 1 creosote and 20 per cent crude oil, 6.75 lb. per cu. ft. Put in track February, 1910. Only 6 ties have been removed to July, 1928, after 18 years of service.

Conclusion

It is recommended that this report be accepted as information and the subject be continued.


ANNUAL TIE RENEWALS PER MILE
Average by years
Five-year average
Cumulative average from 1915
TIES PER MILE
270 260 250 240 230 220 210 200 190 180 170
YEAR
1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927

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29 [illegible]	7	254	
91 174	5	256	
36 [illegible]	4	234	
[illegible]	3	229	
91 [illegible]	3	223	262
[illegible]	4	[illegible]	[illegible]
[illegible] 55[illegible]	9	[illegible]	[illegible]
111 [illegible]	9	247	[illegible]
[illegible]	19	242	[illegible]
[illegible]	22	234	24
[illegible]	6	239	[illegible]
12[illegible] 20	[illegible]	252	[illegible]
56 [illegible]	[illegible]	[illegible]	[illegible]
15[illegible]	[illegible]	266	[illegible]
181 [illegible]	26	236	[illegible]
123 3[illegible]	26	265	241
[illegible] 072	26	213	[illegible]
[illegible]	26	267	[illegible]
[illegible]	26	99	236
[illegible]	26	[illegible]	227
[illegible]	26	[illegible]	[illegible]
[illegible]	[illegible]	212	[illegible]
[illegible]	26	[illegible]	[illegible]
[illegible]	26	[illegible]	[illegible]
[illegible]	26	62	134
[illegible]	29	[illegible]	194
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]

Appendix D

(4) REPORT ON PILING USED FOR MARINE CONSTRUCTION

Dr. Hermann von Schrenk, Chairman, Sub-Committee; W. G. Atwood, C. S. Burt, C. C. Cook, Andrew Gibson, W. H. Kirkbride and G. C. Stephenson.

The Sub-Committee submits its report on the recent inspections of the long time test pieces prepared by the Chemical Warfare Service, some of its own members, the Army, Navy and other co-operators. This report is submitted as information.

1. Immune Timber and Mechanical Protection

ANGELIQUE (*Dicorynia paraënsis, Benth*)

New York, New Haven & Hartford Railroad.

Slades Ferry, Conn., installed July 17, 1923, no attack to September 11, 1928.

Southern Pacific Company.

Galveston, Texas, installed July 11, 1923, no attack to August, 1928.

Florida East Coast Railway.

St. Augustine Florida, installed July 31, 1923, no attack in 1927. Test block lost in 1928.

Panama Canal.

Miraflores, C. Z., installed September 17, 1923, on October 16, 1926, there were no signs of attack, but on August 29, 1928, while there was no evidence of teredo attack there was considerable damage by limnoria.

MANBARKLAK (*Lecythis ollaria, L*)

New York, New Haven & Hartford Railroad.

Slades Ferry, Conn., installed July 17, 1923, no attack to September 11, 1928.

Southern Pacific Company.

Galveston, Texas, installed July 11, 1923, no attack to August, 1928.

Florida East Coast Railway.

Key West, Fla., installed August 5, 1923. The limnoria attack previously reported has continued. The total depth of penetration in September, 1928, was about 1¼ inches.

Panama Canal.

Miraflores, C. Z., installed September 17, 1923, six teredo openings were found, one of which was 1¼ inches long on October 16, 1926. On August 29, 1928, there appeared to be more teredo holes than when previously examined, but they were all small and every one that was opened up was small. There was some attack by limnoria.

GREENHEART *(Nectandra rodioci, Schomb)*

Panama Canal.

Miraflores, C. Z., installed September 17, 1923. This piece much worse than at last examination and quite likely that it will have to be classed out at next examination.

TURPENTINE WOOD (*Syncarpia laurifolia, Tenore*)

New York, New Haven & Hartford Railroad.

Slades Ferry, Conn., and Warren, R. I., installed July 14, 1924. Condition same on September 11, 1928, as on previous reports.

Florida East Coast Railway.

Key West, Fla., installed June 10, 1924. Sapwood attacked in 1926.

U. S. District Engineer, Charleston, S. C.

Castle Pinckney, S. C., installed June 24, 1924. One of the two specimens was found in October, 1928, to be in same condition as at the last inspection; that is, the sapwood was heavily attacked but the heart wood was not. The other specimen was heavily attacked on the end and not so heavily elsewhere.

SHEATHED PILES

Lighthouse Service.

Key West, Fla., installed May 21, 1923, inspected October 8, 1928. Copper sheathed pile has an oxide coat above water and is covered by marine growth below. Piles sound.

Monel sheathed pile in about the same condition.

Cat Island Light, installed February 21, 1923 (copper), and May 23, 1923 (monel). There has been very little deterioration of the monel metal sheets over that which was reported after the examination made on April 13th, 1926. (See A.R.E.A. Proceeding, Vol. 28, page 1133, 1927.)

The monel metal had a greenish appearance whereas the copper sheets showed a copper color through the verdigris forming on same. There were no barnacles on the copper sheets, but on the monel metal sheets there were a few barnacles which were easily pushed off with an oar, and while the monel metal was discolored in spots where the bnarnacles were located, it did not appear that there were any further signs of deterioration under the barnacles as compared to other visible portions of the monel metal sheets.

Panama Canal.

By courtesy of Colonel Harry Burgess, Governor of the Canal Zone, we are able to present a full report on tests being made there.

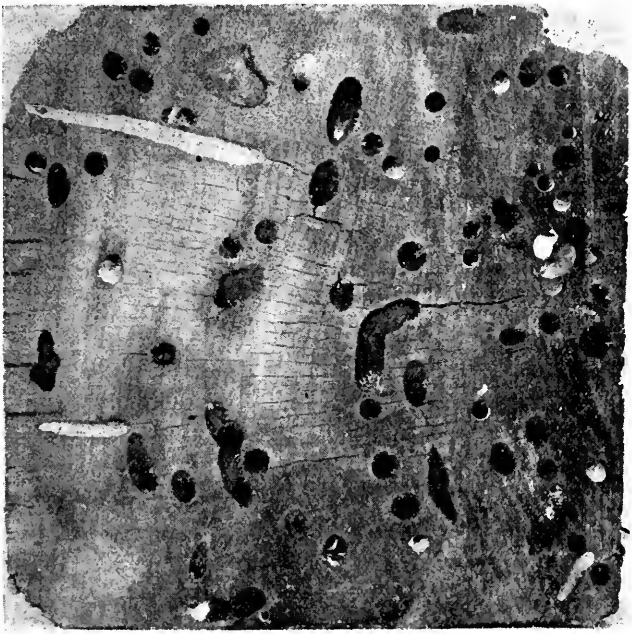


FIG. 1—ALMENDRO FROM PANAMA; SUBMERGED SEPTEMBER 15, 1923, LOWER END OF MIRAFLORES LOCKS. SECTION CUT FROM LOWER END SEPTEMBER 28, 1928. WORK OF NEOBANKIA ZETEKI BARTSCH.

SUBMERGED SEPTEMBER 17, 1923

Name of Wood	*From*	*Inspected*	*Condition*
Almendro	Panama	10/16/26	Well infected with teredo. A year ago there were a few small ones. Their size was not determined.
		8/29/28	Sample has 8-inch square cross section. It was much more infested than in 1926. Intensity of attack shown on Fig. 1.
Apitong (Creosoted)	Philippine I.	10/16-26	No sign of teredo.
		8/29/28	Specimen lost.
Malabayabas	Philippine I.	10/16-26	This is a very heavy wood. The flat surfaces showed no teredo openings but, when a chamfer was cut along one edge, three teredo ranging from one inch to almost two inches were found alive. The biggest had a head $\frac{3}{16}$ inch in diameter. Barnacles were very abundant.

Name of Wood	*From*	*Inspected*	*Condition*
Malabayabas	Philippine I.	8/29/28	There were many more teredo openings than when examined in 1926. Chamfering an edge revealed many more teredos.
Foengo	Dutch Guiana	10/16/26	One teredo opening was found but the burrow was only about ⅜ inch long and no animal present. It would appear that the teredo started and quit, i.e., died.
		8/29/28	No further evidence of teredo. Limnoria practically negligible.
Anaoura	Dutch Guiana	10/16/26	No evidence of teredo.
		8/29/28	No evidence of teredo and practically no danger from limnoria.
Spense Hodoe	Dutch Guiana	10/16/26	No teredo found.
		8/29/26	No teredo or limnoria found.
Ingi Barki	Dutch Guiana	10/16/26	Fifteen burrows counted and many more openings visible. Burrows ranged from 1 to 3 inches in length and had living teredo.
		8/29/28	This sample is decidedly worse than when last examined. The surface is badly riddled and the limnoria has also damaged it.

Submerged October 26, 1925

Name of Wood	*From*	*Inspected*	*Condition*
Kajol Malas	Sumatra	10/16/26	Twelve teredo openings found. No attempt was made to uncover burrows; only a narrow chamfer was cut on the edge.
		8/29/28	It appeared that there were more teredo holes than previously. The limnoria was abundant and the surface, particularly on one side, was badly chewed up.
Kajol Lara	Sumatra	10/16/26	Several small openings were found; two teredo burrows, one ¾ inch long and the other 1½ inches long, were uncovered.
		8/29/28	No change, no signs of limnoria.
Kolaka	Sumatra	10/16/26	Apparently O.K.
		8/29/28	Apparently O.K.

Experiments were also made by submerging (May 11, 1927) specimens of fir covered with copper wire screening, both in single and double layers. These were not a success.

On October 19, 1927, test pieces treated and furnished by Montan, Inc., were submerged. The pieces were reported to have been treated as follows:

A-8 containing 62½% by weight of Montan wax.
A-1 containing 93 % by weight of 50% Montan—50% creosote.
A-5 containing 80 % by weight of 60% Montan—40% creosote.
A-7 containing 30¾% by weight of 40% Montan—60% creosote.

None of these pieces show attack.

The location of the tests has been changed from the lower end of the Miraflores Locks to an outlet tunnel of the uncompleted dry dock at Balboa.

Chemical Warfare Service Specimens

The specimens were treated by the Chemical Warfare Service at the Edgewood Arsenal as follows:

No. 1—A 1 per cent solution of ammoniacal copper carbonate.
No. 2—1 per cent diphenylamine chlorarsene in creosote.
No. 3—.75 per cent diphenylamine chlorarsene and .5 per cent phenyldichlorarsene in fuel oil.

Inspection reports are as follows:

No. 1—Test Pieces.

New York, New Haven & Hartford Railroad.

Installed May, 1925, at Warren, R. I., showed no attack on September 11, 1928.

U.S. District Engineer, Charleston, S. C.

Installed May 12, 1925, at Castle Pinckney, S. C., inspection showed rather severe attack on one side of test piece by both limnoria and teredo. The remainder of the piece is intact. This attack was the result of poor treatment, there being a zone where very little penetration was obtained.

Florida East Coast Railway.

Installed September 21, 1925, at Key West, Fla. Slight attack by limnoria was evident at inspecting September, 1928.

U.S. Navy, Pensacola, Fla.

Installed June 5, 1925, at the Air Station. No attack visible August 30, 1928.

Lighthouse Service, San Juan, P. R.

Installed July 1, 1925, at San Juan. No attack apparent on August 29, 1928.

U.S. Navy, Coco Solo, C. Z.

(A) Installed July 23, 1925, in front of Quarters E Submarine Base. Inspected September 22, 1928, when very slight evidence of teredo attack was found, by none of limnoria attack.

(B) Installed August 11, 1925, at boathouse building No. 24. Inspected September 22, 1928, when no attack was evident.

The growth of barnacles on these pieces is very small, estimated at 5 per cent of the surface on (A) and 2 per cent on (B). (Fig. 2.)

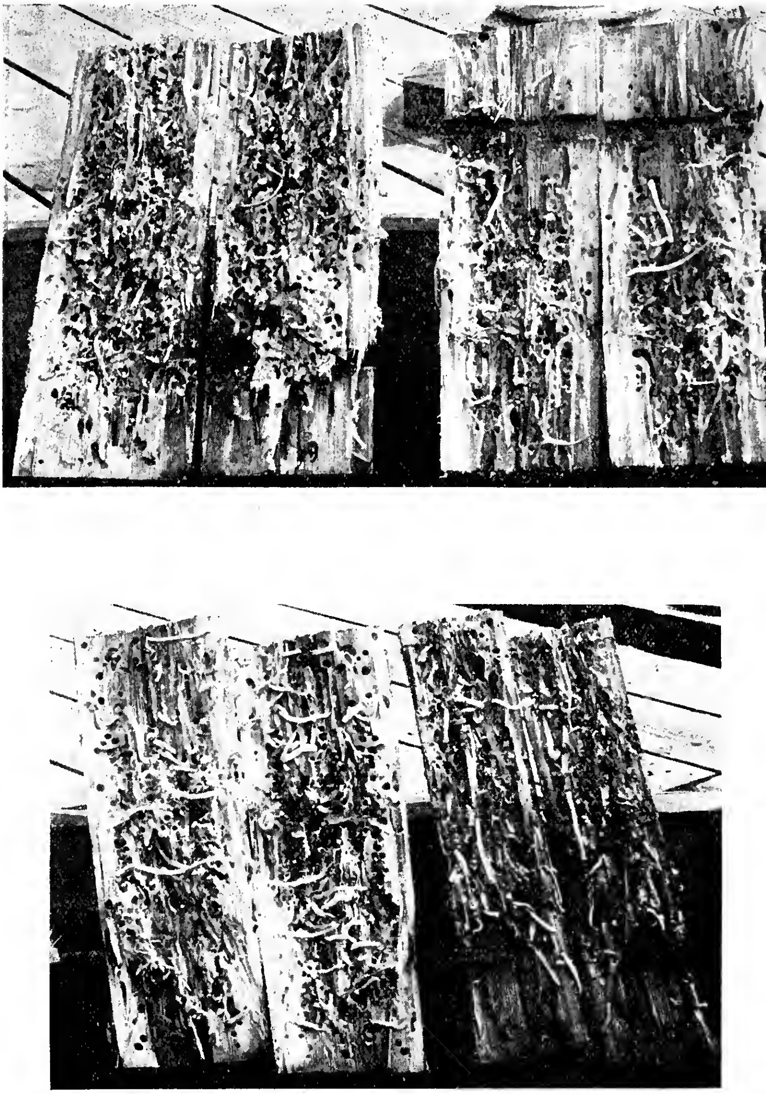


Fig. 2—Untreated Control Pieces

Southern Pacific Company.

Oakland Pier, Cal., installed July 21, 1925. No attack shown by inspection in September, 1928.

Ferry Slip, Port Costa, Cal., installed July 22, 1925. No attack shown by inspection in September, 1928.

U.S. Navy, Bremerton, Wash.

Puget Sound Navy Yard, Pier No. 4, installed October 14, 1925. No attack found by inspection September 18, 1926, though untreated control piece was heavily attacked. (Fig. 3.)

Puget Sound Navy Yard, Pier No. 8, installed November 3, 1925. No attack found by inspection September 18, 1928.

U.S. Navy, Pearl Harbor, H. I.

Coaling Pier, Naval Operating Base, installed August 17, 1925. Fairly heavy limnoria attack was in evidence at inspection of September 5, 1928.

No. 2 Test Pieces

New York, New Haven & Hartford Railroad.

Warren, R. I., installed May, 1925. No attack found by inspection of September 11, 1928.

U.S. District Engineer, Charleston, S. C.

Castle Pinckney, S. C., installed May 12, 1925. No attack found at inspection of September, 1928.

Florida East Coast Railway.

Key West, Fla., installed September 21, 1925. Slight limnoria attack shown by inspection of September, 1928.

U.S. Navy, Pensacola, Fla.

Air Station, installed June 5, 1925. No attack visible at inspection of August 30, 1928.

Lighthouse Service, San Juan, P. R.

Installed July 1, 1925, at San Juan. No attack found at inspection of August 29, 1928.

U.S. Navy, Coco Solo, C. Z.

Submarine Base, (A) installed July 23, 1925, in front of Quarters E. No evidence of attack on September 22, 1928.

(B) Boathouse building No. 4, installed August 11, 1925. No attack in evidence on September 22, 1928.

Southern Pacific Company.

Oakland Pier, Cal., installed July 21, 1925. No evidence of attack on September, 1928.

Ferry Slip, Port Costa, Cal., installed July 22, 1895. No evidence of attack September, 1928.

U.S. Navy, Bremerton, Wash.

Puget Sound Navy Yard, Pier No. 4, installed November 3, 1925. No evidence of attack on September 18, 1928.

Puget Sound Navy Yard, Pier No. 8, installed November 3, 1925. No evidence of attack on September 18, 1928.

U.S. Navy, Pearl Harbor, H. I.

Coaling Pier, Naval Operating Base, installed August 17, 1925. A few limnoria were found in a check but otherwise the piece was not attacked on September 5, 1928.

No 3 Test Pieces

New York, New Haven & Hartford Railroad.

Warren, R. I., installed May, 1925. No attack found by inspection September 11, 1928.

U.S. District Engineer, Charleston, S. C.

Castle Pinckney, S. C., installed May 12, 1925. No attack found at inspection of September, 1928.

Florida East Coast Railway.

Key West, Fla., installed September 21, 1925. Slight limnoria attack found at inspection of September, 1928.

U.S. Navy, Pensacola, Fla.

Air Station, installed June 5, 1925. No attack found at inspection of August 30, 1928.

Lighthouse Service, San Juan, P. R.

San Juan, installed July 1, 1925. This piece showed fairly heavy limnoria and teredo attack at inspection of August 29, 1928.

U.S. Navy, Coco Solo, C. Z.

(A) In front of Quarters E Submarine Base, installed July 23, 1925. Three per cent to 10 per cent showed both limnoria and teredo attack at inspection, September 22, 1928.

(B) Boathouse building No. 4, installed August 11, 1925; 25 per cent of the area was attacked by *limnoria* and there was some teredo action observed at the inspection of September 22, 1928. (Fig. 4.)

Southern Pacific Company.

Oakland Pier, Cal., installed July 21, 1925. No evidence of attack in September, 1928.

Ferry Slip, Port Costa, Cal., installed July 22, 1925. No evidence of attack in September, 1928.

U.S. Navy, Bremerton, Wash.

Puget Sound Navy Yard, Pier No. 4, installed November 3, 1925. There was no evidence of attack and the softening of the timber reported last year had not progressed.

Puget Sound Navy Yard, Pier No. 8, installed November 3, 1925. No evidence of attack on September 18, 1928.

U.S. Navy, Pearl Harbor, H. I.

Coaling Pier Naval Operating Base, installed August 17, 1925. This test piece was severely damaged by both teredo and limnoria. The wood was soft and spongy and had been attacked by limnoria over the entire surface to an average depth of ⅜ inch. Several teredo burrows had been exposed by the limnoria attack.

San Francisco Bay Tests

Report of inspection September 12, 1928, of specimens furnished through Dr. Hermann von Schrenk and Col. Wm. G. Atwood, and installed in San Francisco Bay. For detailed description of the oils used in this test see pages 144-148, "Marine Structures, Their Deterioration and Preservation," by Atwood and Johnson, 1924.

(P = Pine. F = Fir.)

Barrett Manufacturing Company Material

Placed Station B, Pier No. 7, San Francisco, January, 1923. Moved to Biological Station, Oakland Pier, c/o Southern Pacific Company, December, 1925 . No attack except slightly limnoria.

Gate No	*Specimen No.*	*Treatment*	*Condition September 12, 1928*
B- 4	P 1 2 3 4	Coke oven original oil —solids removed —acids removed —bases removed	P 1 intact. P 2, 3 and 4 slightly eroded by *limnoria* on ends; sides slightly attacked near ends.
B- 5	P 5 6 7 8	Coke, minus residue above 360 deg. C. Coke, minus fraction 230-270 deg. C. Coke, minus fraction up to 230 deg. C. Coke, minus fraction 270-360 deg. C.	All slightly eroded by *limnoria* on ends. P 5 also on sides next to end. P 8 slightly worse.
B- 6	P 9 10 11 12	Vertical retort original oil —minus solids —minus acids —minus bases	All slightly eroded by *limnoria* on ends; sides intact.
B- 7	P 13 14 15 16	—minus residue above 360 deg. C. —minus fraction 230-270 deg. C. —minus fraction up to 230 deg. C. —minus fraction 270-360 deg. C.	No attack.
B- 8	F 1 2 3 4	Coke oven oils duplicating B-4 in identical order.	All slightly eroded on ends. On sides attack confined to line across specimens where gate had rubbed against a submerged brace.
B- 9	F 5 6 7 8	Coke over oils duplicating B-5 in identical order.	All slightly eroded on ends. Only traces on sides.
B-10	F 9 10 11 12	Vertical retort oils duplicating B-6 in identical order.	All show slight erosion on both ends and sides.

B-11	F 13 14 15	Vertical retort oils duplicating B-7 in identical order.	Erosion on all ends, not severe but deeper than on preceding. On sides generally light but deeper in spots. F 13 shows several *limornia* burrows around a knot.

Note.—A careful inspection of these test pieces shows no appreciable change in condition since last inspection one year ago.

1927 Report on Test Piles

For original description of these piles see:

1. Am. Wood Pres. Asso., 1920, pages 148-178.
2. Marine Structures, Their Deterioration and Preservation, Atwood and Johnson.

See previous A.R.E.A. Reports:

Vol. 23—1922, page 959.
Vol. 27—1926, page 989.
Vol. 27—1927, page 1155.
Vol. 29—1928, page 723.

The following tables, 1-A to 1-D, give the 1928 condition of four sets of test piles driven in 1919 and 1920 at Seattle, Tiburon in San Francisco Bay, San Pedro and San Diego. Each set originally consisted of seven piles, including the following:

3 old creosoted fir piles originally driven in 1890—Table 1-A.
1 old creosoted fir pile originally driven in 1901—Table 1-B.
2 new freshly creosoted fir piles.
1 new untreated fir pile.

The untreated piles were destroyed in three or four years as shown in Table 1-D, leaving six piles in each set.

The set at San Diego was exposed for test by the A.T.&S.F. Railway Company in their Wharf No. 63, until this wharf was dismantled in July, 1925. After being repaired they were redriven by the Southern Pacific Company at Long Beach, Cal., and the test continued.

Test Piles—Table 1-A—Creosoted Fir Piles from Southern Pacific Company Old Long Wharf Dock "A," Oakland. Originally Driven in 1890. Pulled in 1919 and Redriven Elsewhere. Exposed to Marine Borer Attack Thirty-Eight Years to Date

Mark	*Date*	*Redriven for Test Railroad*	*Location*	*1928 Inspection Remarks*	*Borers*
A- 6	1920	N.P. Ry. Co.	Seattle	No attack to date	....
A- 8	1920	N.P. Ry. Co.	Seattle	This pile now free of teredo. Spots reported last year cannot now be located	....
A-32	1920	N.P. Ry. Co.	Seattle	No attack to date	....
A-19	1919	N.Y.P. R.R. Co.	Tiburon*	No attack to date	....
A-28	1919	N.Y.P. R.R. Co.	Tiburon*	No attack to date	....
A-29	1919	N.Y.P. R.R. Co.	Tiburon*	No attack to date	....

Mark	Date	Redriven for Test Railroad	Location	1928 Inspection Remarks	Borers
A- 5	1919	S.P. Co.	San Pedro	Slight *limnoria* erosion in 3 spots; no change since last year	Limnoria
A-20	1919	S.P. Co.	San Pedro	Slight limnoria erosion; no change since last year	Limnoria
A-34	1919	S.P. Co.	San Pedro	2 holes 3 inches deep by *limnoria*—no change since last year	Limnoria
A- 2	1920	A.T.&S.F. Ry.	San Pedro	Pulled, 1925	....
A- 2	1925	S.P. Co.	Long Beach	Holes attacked by *limnoria* repaired 1925 and attack stopped, no further attack to date	Limnoria
A- 7	1920	A.T.&S.F. Ry.	San Diego	Pulled, 1925	....
A- 7	1925	S.P. Co.	Long Beach	Hoes attacked by *limnoria* repaired 1925 and attack stopped, no further attack to date	Limnoria
A-33	1920	A.T.&S.F. Ry.	San Diego	Pulled, 1925	....
A-33	1925	S.P. Co.	Long Beach	Holes attacked by *limnoria* repaired 1925 and attack stopped, no further attack to date	Limnoria

Test Piles Table 1-B—Creosoted Fir Piles from Southern Pacific Company Old Long Wharf Dock "E," Oakland. Originally Driven in 1901. Pulled in 1919 and Redriven Elsewhere. Exposed to Marine Borer Attack Twenty-Seven Years to Date

Mark	Date	Redriven for Test Railroad	Location	1928 Inspection Remarks	Borers
E-46	1920	N.P. Ry. Co.	Seattle	Slight *teredo* attack in small check, otherwise pile OK	Teredo
E-42	1919	N.W.P. Ry.	Tiburon*	2 holes attacked by *limornia* repaired in 1924; a further slight attack has occurred	Limornia
E-38	1919	S.P. Co.	San Pedro	Slight attack by *limnoria*. No change since last year	Limnoria
E-50	1920	A.T.&S.F. Ry.	San Diego	Pulled in 1925	....
E-50	1925	S.P. Co.	Long Beach	Old scorings by *limnoria* repaired in 1925, slight *limnoria* attack during 1927. No further change	Limnoria

A

Test Piles—Table 1-C—Freshly Creosoted Fir Piles, Exposed to Marine Borer Attack Eight Years to Date

Mark	Date	Redriven for Test Railroad	Location	1928 Inspection Remarks	Borers
47	1920	N.P. Ry. Co.	Seattle	No attack to date.	
48	1920	N.P. Ry. Co.	Seattle	*Teredo* active in 3 foot check at mud line. Spots reported last year have not advanced. Pile still in good condition.	Teredo
43	1919	N.W.P. R.R.	Tiburon*	No attack to date	....
44	1919	N.W.P. R.R.	Tiburon*	No attack to date	....
40	1919	S.P. Co.	San Pedro	No attack to date	....
41	1919	S.P. Co.	San Pedro	No attack to date	....
51	1920	A.T.&S.F. Ry.	San Diego	Pulled, 1925.	....
51	1925	S.P. Co.	Long Beach	Holes attacked by *limnoria* repaired in 1925. Attack stopped. No further attack to date.	Limnoria
52	1920	A.T.&S.F. Ry.	San Diego	Pulled, 1925	....
52	1925	S.P. Co.	Long Beach	Holes attacked by *limnoria* repaired in 1925. Attack stopped. No further attack to date.	Limnoria

Untreated Fir Piles. Exposed to Marine Borer Attack

Mark	Date	Redriven for Test Railroad	Location	1928 Inspection Remarks	Borers
49	1920	N.P. Ry. Co.	Seattle	Broken off at mud line, 1923.	Limnoria Bankia
45	1919	N.W.P. R.R. Co.	Tiburon*	Broken off at mud line, 1923.	Limnoria Bankia Teredo Navalis
39	1920	A.T.&S.F. Ry.	San Diego	Broken of at mud line, 1923.	Limnoria Probably Bankia

*San Francisco Bay.

New Tests

The Committee has distributed a series of new test pieces treated to refusal with a 6 per cent Ac-Zol solution to the stations where the Chemical Warfare Service specimens are located. These tests pieces were treated and distributed by the courtesy of the Norfolk Creosoting Co.

Summary

The tests of tropical timbers are still inconclusive so far as some species are concerned, but as is the case with timber treated with preservatives it appears that it is much more difficult to protect against *limnoria* than *teredo.*

Turpentine wood still shows a good record except for one specimen in Charleston, S. C. The Panama Canal organization is arranging for exhaustive tests of this timber.

Some of the Chemical Warfare Service specimens are showing signs of failure but those specimens which the members of the Committee have been able to inspect appear to be poorly treated.

The San Francisco tests of various creosotes are still inconclusive because of light attack so far.

The "Long Wharf" piles continue to resist attack after 38 years' service.

Recommendations

It is recommended that the work of this Sub-Committee be continued with no change of plan.

It is recommended that on account of the increasing activity of termites that a study of methods of protection against this menace be either assigned to this Sub-Committee or that a new Sub-Committee be organized for its study.

EIGHTH INTERIM REPORT

DETERIORATION OF STRUCTURES IN SEA WATER

"Sea Action Committee," Institution of Civil Engineers

This report includes work done and inspections made during the year preceding March 31, 1927.

Corrosion Tests

The Committee prepared identical test sets of various metals for experiments at Halifax, N. S., Auckland, N. Z., Colombo, Ceylon and Plymouth, Eng. Three series were installed at each location to be examined at the end of 5, 10 and 15 year periods. The five-year period having expired this report gives the results of laboratory examination of the Halifax test pieces.

Three sets each containing all the different metals to be tested were placed, one above high tide, one about half tide and one below low tide. A series made up of the different metals in contact was also installed in the same manner. Sixteen different steels and irons were included.

The conclusions of the laboratory follow:

"1. There is, in general, but little difference between the rates of corrosion of Low Moor wrought iron and mild steel when exposed to complete immersion in the sea. In alternate wet and dry tests the advantage lies with the wrought iron, but in the aerial tests the mild steels proved distinctly superior. The wrought iron on corrosion shows its typically fibrous structure." (Swedish charcoal iron and Armco iron did not give as good results as Low Moor.)

"2. The presence of sulphur in steel tends to enhance its rate of corrosion."

"3. The presence of copper, up to about 2 per cent, enhances to an appreciable extent the resistance of the metal to corrosion."

"4. Chromium and nickel steels are very resistant to sea air and to alternate exposure to sea-water and air. Under conditions of continuous immersion in sea water, the advantage over wrought iron and carbon steels is less marked in so far as loss in weight is concerned; they are, moreover, liable to very severe pitting."

"5. The cast irons apparently proved the most resistant metals to corrosion when loss in weight and freedom from pitting are considered together. In certain cases, however, there is evidence of internal corrosion and this is being investigated."

"6. When dissimilar metals are placed in contact, or riveted or bolted together, there is a tendency for one of the metals to be preserved from corrosion at the expense of the second, which corrodes very severely. This is specially noteworthy when mild steel bolts, rivets or bars are in contact with chromium and nickel steels, the mild steel undergoing rapid disintegration, whilst the alloy steel remains practically perfect."

"7. In general, bars that had been ground free from scale before exposure lost less in weight and appeared somewhat less deeply pitted than those exposed with their scale still adhering."

"8. Attention is directed to the extreme danger of drawing conclusions from isolated and unconfirmed tests, inasmuch as the results are very prone to be influenced by factors often unknown to, and beyond the control of, the investigator."

The conclusions from the study of the five-year tests at Auckland, N. Z., are very similar to those quoted above for Halifax.

The difference between the mild steels and wrought iron seemed to be slightly less and the high sulphur, high phosphorus bars were not so much worse than the others at Auckland as they were at Halifax.

It appeared from the Auckland tests that copper bearing steel with 2.185 per cent copper was less resistant than one with 0.635 per cent. This was the same at Halifax and it would appear that 2 per cent was the allowable high limit for copper.

Paint Tests

A large series of plates coated with various protective coatings were exposed at Southampton, England, May 12, 1924. The series totally immersed and exposed at half tide have been previously reported and this year a report is submitted on the series exposed to aerial corrosion.

Nineteen coatings were used and in general it may be said that the iron oxide-Calcutta oil, iron oxide-litho oil and galvanized plates are the only ones that are good. None of the coal tar coatings were effective.

Another series of plates (220) were placed at Southampton, March 27, 1925, and their preparation is fully described. The test is not finished.

Wood Preservation

Test blocks impregnated with various compounds are being maintained in harbors in England and in the Far East. The time of immersion of these specimens is not yet long enough to justify drawing final conclusions but the investigators express the opinion that D.A. oxide will not form a valuable preservative, while D.M. is more promising. (This agrees with the laboratory indications of the Chemical Warfare Service, U.S.A.)

A physiological study of limnoria and chelura has been carried on. It was found that these animals did not digest any of the wood particles which pass through. This explains the greater resistance to toxics of the crustaceans than the mollusks.

The report reads as follows: "The crustacean borers must be considered as providing a separate problem from that of the molluscan borers. Firstly..the adult and not the larvæ carries infection, the latter being protected by the parent burrow during what is probably the period when it is most susceptible to attack. Secondly, owing to the difficulty of injuring them by means of poisons injected into the wood which they swallow, treated timber which would otherwise be immune is rendered liable to the attack of *Teredinidæ* by the previous action of the crustacean borers."

Northern Pacific Experiments and Tests

The harbors of Seattle and Tacoma are locations of very great marine borer activity and, therefore, the following service records of piles furnished by the Northern Pacific Railway are of great interest.

Pier No. 1, Seattle. This dock was originally constructed with 1500 "Perfection" piles in 1901. In 1908 all but 75, which were above low tide, were replaced by 1520 creosoted piles. On account of extensions and rearrangements 1562 more creosoted piles were driven in 1909, 545 in 1912 and 84 in 1922. Replacements in 1917 and 1925 were 744 piles or 20.4 per cent, the larger portion of which replaced 1912 piles.

Pier No. 2, Seattle. Originally constructed in 1902 with 1735 "Perfection" piles, 1435 creosoted piles were used for replacements in 1907-08 and 1566 for extensions in 1909. Total replacements 394 piles, or 13.1 per cent, in 1917-18, and 333, or 11.1 per cent, in 1925, the larger portion replacing 1909 piles which seem to have less resistance than 1908 piles.

Pier No. 3, Seattle. Constructed in 1900 with 1087 "Perfection" piles. Replacements 1906 to 1910 were 1202 piles; 334, or 27.8 per cent, of these creosoted piles were replaced between 1912 and 1925, most of them in 1918 and 1925.

Pier No. 4, Seattle. Constructed in 1902 on 1318 "Perfection" piles which were replaced in 1909. Replacements since that time were 193 piles, or 14.6 per cent.

Pier No. 5, Seattle. Constructed in 1901 with 1354 "Perfection" piles which were all replaced between 1906 and 1913. Since that time replacements have been over 60 per cent because of certain studies which required pulling the piles.

West Seattle Elevator. Constructed in 1908-09 on 1354 creosoted piles of which only 4 per cent have been replaced. Borer activity in this location is less than on the opposite side of the Bay.

Northwestern Dock, Tacoma. Originally constructed in 1900 on "Perfection" piles which were replaced in 1903 and 1908. Of these piles 80 per cent have been replaced. These piles were driven through rip-rap, and were damaged in driving.

London Dock, Tacoma. The history of this dock is similar to that of the Northwestern and the reasons for failure are the same. Over 90 per cent of the creosoted piles driven 1903-1908 have been replaced.

Balfour & Guthrie Docks, Tacoma. History is the same as above. Replacements of 1903-08 creosoted piles 83 per cent.

Eureka Dock, Ocean Warehouses No. 1 and No. 2, Tacoma. History same as above. Replacements from 70 to 80 per cent.

The creosote used in the treatments all came from Germany and had an average analysis as follows:

Specific gravity at 38 deg. C	1.067
Water	Trace
To 210 deg.	3.167
To 235 deg.	9.452
To 270 deg.	28.132
To 315 deg.	55.455
To 355 deg.	81.791
Residue	Soft and Plastic
Treatment—boiling under vacuum	
Average time boiling	22 hours
Average time pressure	3 hours
Pressure used	100 to 190 lb.
Average absorption	14.5 lb. per cu. ft.
All piles Douglas Fir	

Test of Special Treatment

Test blocks treated with 13.3 lb. crude oil placed in the water June 23, 1925, were unattacked when first examined on June 25, 1926, but were cut in half at the time of that inspection. They were replaced in the water and examined on April 20, 1928, when all were found to be attacked by *Bankia,* entering principally from the cut ends.

Other blocks were treated with a mixture of 80/20 creosote coal tar solution 50 per cent and crude oil 50 per cent. Treatment 18 lb. per cu. ft. These blocks showed no attack after 3 years 10 months immersion.

Another group of test blocks were treated as follows:

(A) Crude oil 18 lb. per cu. ft. full cell.
(B) Lowry process 50 per cent—80/20 creosote coal tar solution, 50 per cent crude oil, 13 lb. per cu. ft.
(C) Rueping process 50 per cent—80/20 creosote coal tar solution, 50 per cent crude oil, 9.4 lb. per cu. ft.
(E) Rueping process A.R.E.A. No. 1 creosote, 6.2 lb. per cu. ft.

These blocks were immersed Oct. 22, 1926, and on examination one year and five months later it was found that none of them had been attacked. Two pieces with treatments "A" and "B" which had been immersed two years and two months and three years and ten days had been lightly attacked.

Two specimens were treated by what was known as the "Electro Copper Plating Process." These pieces were prepared by being given a copper sulphate treatment and then covered by a very thin coating of metallic copper.

The test pieces were immersed March 20, 1926, and inspected about two years later. The inspection report is as follows: "The thin layer of copper is wearing away pretty fast. The round piece is a sapling of Douglas Fir 36 inches long and 6 inches diameter, with half thoroughly covered with copper plating and the other half uncovered but treated with copper sulphate solution. The copper covered end was in fine shape with the copper in perfect condition and absolutely free from teredo. The other half of the piece treated only with the sulphate solution was honeycombed with teredo on one side."

Lake Maracaibo

Information has come to some of the members of this Committee concerning heavy losses suffered by the oil companies operating in Lake Maracaibo, Venezuela, which thoroughly illustrate the care necessary in the use of timber in borer infested waters.

Lake Maracaibo is an oval body of water connected with the Gulf of Venezuela and the Caribbean by a rather short and comparatively shallow passage. It is fed at the south end and around its periphery by several large and a number of small rivers. The salinity of the water is unknown but it is undoubtedly low, at least at the south end of the lake.

The oil companies are drilling wells in the bottom of the lake and their derrick foundations and communicating structures are on piles. The species, period of activity and other data regarding the borers has not as yet been determined, but studies have been commenced and results will be made available when obtained.

One company alone has driven over 36,000 piles from July, 1925, to April, 1928, at a total cost in place of about $1,350,000 and there are several companies working in the lake. It is stated as a result of inspection that probably two-thirds of these piles were unsafe in April, 1928.

The treatment varied from 8 lb. to 14 lb. per cu. ft. with creosote of varied and unknown specifications.

Some untreated oak and pine piles have been used but the usual life of untreated timber is generally only a few months (Fig. 1), though some of them have lasted as long as some of the treated piles.

This light treatment and the lack of precaution as to the quality of the creosote used readily explain the failures.

It is entirely possible that there are previously unknown species of teredo in the lake and that some of them are working in fresh water.

The investigations now being initiated by one of the companies in which some members of this Committee are co-operating should furnish much valuable information.

Some native timbers Gateado (*Astronium graveolens*) and Mapora (*Cenocarpus mapora*) were, according to local traditions, resistant, but trial has shown that the resisting qualities have been much exaggerated. Some manbarklak piles driven in 1925 show only a very light attack in 1928.

Appendix E

(5-a) STUDY AND REPORT UPON EFFECT OF PRESERVATIVE TREATMENT BY THE USE OF CREOSOTE AND PETROLEUM

G. C. Stephenson, Chairman, Sub-Committee; R. S. Belcher, E. A. Craft, H. R. Duncan, E. B. Fulks, W. R. Goodwin, L. J. Reiser, O. C. Steinmayer, T. H. Strate, Dr. Hermann von Schrenk.

In view of the fact that there have been no radical changes in the ties under observation in the test tracks, the Committee feels that no information other than that already submitted can be presented this year and suggests that the subject be continued for further investigation.

Appendix F

(5-b) STUDY AND REPORT UPON EFFECT OF PRESERVATIVE TREATMENT BY THE USE OF ZINC CHLORIDE AND PETROLEUM

G. C. Stephenson, Chairman, Sub-Committee; R. S. Belcher, E. A. Craft, H. R. Duncan, E. B. Fulks, W. R. Goodwin, L. J. Reiser, O. C. Steinmayer, T. H. Strate, Dr. Hermann von Schrenk.

In view of the fact that there have been no radical changes in the ties under observation in the test tracks, the Committee feels that no information other than that already submitted can be presented this year and suggests that the subject be continued for further investigation.

Appendix G

(6) SPECIFICATIONS FOR TREATMENT OF AIR-SEASONED DOUGLAS FIR

R. S. Belcher, Chairman, Sub-Committee; F. D. Mattos, Vice-Chairman; H. R. Duncan, Andrew Gibson, W. R. Goodwin, R. S. Hubley, W. H. Kirkbride, G. P. MacLaren, L. J. Reiser, Dr. Hermann von Schrenk, G. C. Stephenson, C. M. Taylor.

At the 27th Annual Convention of this Association, Specifications for the Preservative Treatment of Douglas Fir, prepared by this Committee, were adopted for the Manual. These specifications covered both green and seasoned Douglas fir, and were in accordance with best practice at the time. There has been little or no change in methods of treatment since that time and this Committee has secured no information during the past two years which would cause them to recommend the adoption of revised specifications for air-seasoned Douglas fir at this time.

During the year the Committee has made a study of creosoted Douglas fir piling and timbers which have been in service ten to thirty-two years. Forty-two bridges containing creosoted Douglas fir were inspected on the Burlington, Rock Island, Southern Pacific and Santa Fe. It has been the aim of all methods of pressure treatment of wood to secure the greatest depth of penetration of preservative possible, and inasmuch as there is a great variation in depth of penetration in individual pieces of Douglas fir, even after having been treated to refusal by best methods known, it was the object of this study to see how timbers of shallow penetration compared as to length of service with timbers of much deeper penetration of preservative. A large number of borings with increment auger was made, the cores showing penetration ranging from 1/8 inch to 5 inches. The Committee is of the opinion that the information gathered during this study and inspection of bridges is of value and some of the details should be recorded in this report.

On the Louisiana Division of the Rock Island, there are a number of open-deck pile trestles constructed in 1914. These trestles are entirely of creosoted pine with the exception of six stringers in each panel which are of creosoted Douglas fir, size 8x16—30. Two additional stringers in each panel are of creosoted pine, which were added later. The Douglas fir stringers are of both the slow growth and wide ring Douglas fir. All creosoted timber in these bridges was found to be in excellent condition after fourteen years' service and at the time of inspection, the Committee could see no difference in the relative condition of pine and fir or slow growth and wide ring fir.

The fir stringers received an average of 7½ lb. per cubic foot and the method of treatment was as follows:

Initial vacuum 30 minutes, 24 inches.
Oil pressure 2 hours, 175 pounds.
Temperature creosote, introduction 190 degrees, end 170 degrees.
Vacuum 30 minutes, 24 inches.

After this final vacuum, the creosote was reintroduced and the same treatment repeated (known as the German "bumping" process.) Thus the total treatment is as follows:

Initial vacuum 1 hour, 24 inches.
Oil pressure 4 hours, 175 pounds.
Temperature of oil, 190-170 degrees.
Final vacuum 1 hour, 24 inches.

The preservative used for the treatment of the stringers was a distillate creosote having a specific gravity of 1.0481 at 100 degrees Fahr., water 3 per cent and the following fractionation:

Below 200	1.2
200 to 210	1.3
210 235	27.0
235 270	25.5
270 315	17.5
315 355	14.7
Residue	12.8
	100.0

Penetration of creosote in the fir stringers ranged from ¼ inch to 2 inches.

In contrast to the excellent condition of the treated Douglas fir stringers after fourteen years in service, it is interesting to know that the trestles which were replaced by the present structures were of untreated timber and the stringers were of untreated Douglas fir. These bridges were built in 1906, the Committee was informed by Mr. Helwig, Master Carpenter of the Louisiana Division, and the untreated stringers were considerably decayed at bolt holes and points of contact with other timbers. They were unfit for further service at the time the untreated structures were replaced by the present creosoted structures, having given only an eight-year life.

The photographs which follow show three of the Rock Island bridges above referred to. The hand adzing shown at the bearings on the caps was done prior to treatment.

On the Southern Pacific in California, it was the good fortune of the Committee to have the opportunity of examining trestles twenty-seven to thirty-two years old, constructed of treated Douglas fir.

F. D. Mattos, Manager of Treating Plants of the Southern Pacific Lines, advises as follows as to the relative kind of treatment given the timbers in these old bridges:

"While our old records are insufficiently complete to enable us to determine exactly the treatment given the timbers inspected by A.R.E.A. Committee No. 6 in August, the following figures will serve to give a good idea of the methods then used. They are averages for two groups of ten charges each, selected at random from the treatment records of 1895-96 for the first group and 1898 for the second. The exact absorption is not known, but from the records of amount injected and capacity loads of retorts, the gross injection was from 14 to 22 lb. per cubic foot. The net retention probably averaged between 10 and 12 lb. per cubic foot, 12 lb. was the figure we tried to get.

	1895-96			1898		
	Average	*High*	*Low*	*Average*	*High*	*Low*
Bath:						
Time (hours and minutes)	10:15	12:25	7:30	10:30	10:55	9:55
Temperature (deg. Fahr.)	208	212	202	213	220	210
Pressure:						
Time (hours and minutes)	4:30	5:05	3:05	4:35	5:00	4:00
Temperature (deg. Fahr.)	188	200	175	195	200	188
Pressure (pounds)	124	140	110	143	145	135

"We have no actual analyses of the creosote used at that time but during those years the company was receiving oil from England of about the following characteristics:

	Distillation:
Sp. Gr. at 60 deg. Fahr., 1.07.	Up to 200 deg. Fahr., 0.
Point of Fluidity, 90 deg. Fahr.	200-400 deg. Fahr., 15 per cent.
Napthalene, 20 per cent.	400-600 deg. Fahr., 25 per cent.
Tar Acids, 6 per cent.	Residue above 600 deg. Fahr., 33 per cent or less.

"In terms of present day distillation procedure, this would be:

Up to 210 deg. C. 16 per cent.
210-315 deg. C. 24 per cent or more.
Residue above 315 deg. C. 33 per cent or less."

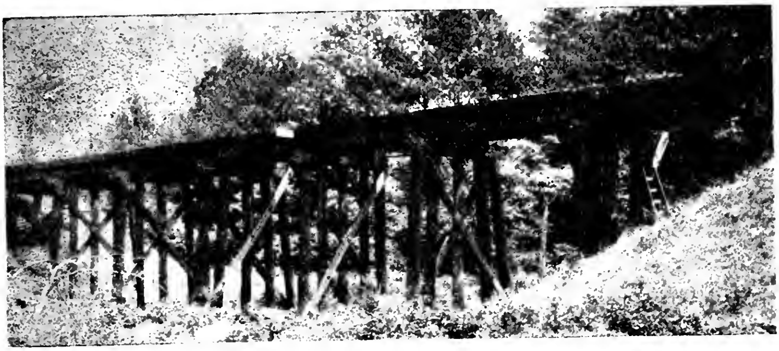
It should be stated that the treatment given these timbers was known as the "Boiling Process" and, in general, the timber was green at the time of treatment. This treatment should be compared with the treatment recommended by the Committee in Volume 27 of the Proceedings of this Association. This latter treatment is known as the Boulton or Boiling Under Vacuum Treatment. Temperatures are somewhat lower in the treatment recommended than was the practice in 1895 to 1898.

The type of construction of these bridges is illustrated by the photographs which follow and the legends on these photographs indicate the relatively small number of replacements of timbers which have been made. It should be noted that all framing was done prior to treatment which, without doubt, contributed materially to the excellent record which has been made by these bridges. It has been observed by your Committee that creosoted timbers coming out of bridges, which have been dismantled, in many cases show one end of the timber badly decayed, the opposite end sound, the decay apparently being due to the fact that one end of the stick was trimmed when it was placed in the structure. Other timbers show failure due to framing of the treated wood at time of construction and there is considerable decay adjacent to bolt holes. Your Committee takes this opportunity to call attention to the importance of doing all trimming and framing possible before treatment.

Comparing the life of untreated Douglas fir bridge timbers with the excellent record made by the treated fir structures, the Committee was advised that untreated Douglas fir decks in the same vicinity as the creosoted structures inspected gave a service life of 12 to 14 years. The difference between this figure and the records on the Louisiana Division of the Rock Island is doubtless explained by the very different climatic conditions in the two locations.

Practically every pile or timber bored in these creosoted fir structures were found to be in sound condition throughout, those of shallow penetration being in as good condition as those of deep penetration, so far as those making the inspection could ascertain. All timbers examined had been given very nearly the same treatment and without doubt the variation in penetration is due to the character of the timber in individual sticks and not to variation in treatment.

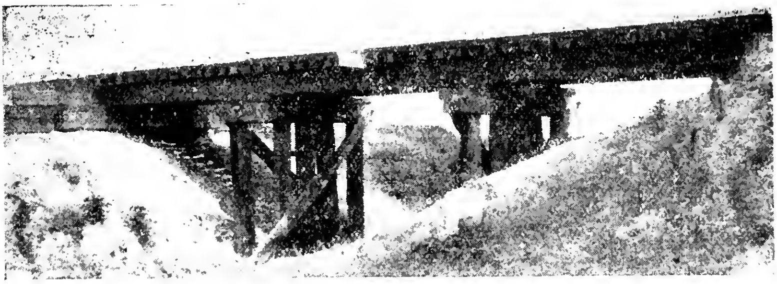
The Committee recommends that the subject be continued.



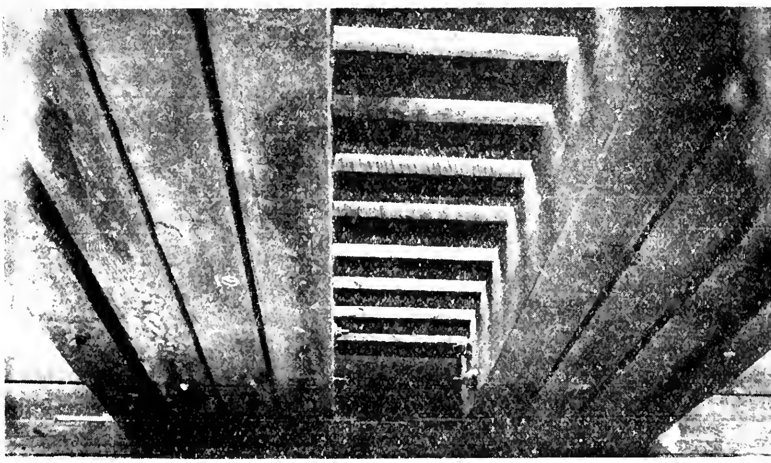
No. 10. C. R. I. & P. bridge 905, between Haskell and Eldorado, Ark. Constructed 1914. Six stringers per panel, creosoted Douglas fir in original bridge. Two additional stringers, creosoted pine, added later. Photographed May 24, 1928.

No. 11. C. R. I. & P. bridge 905, between Haskell and Eldorado, Ark., constructed 1914. View of creosoted Douglas fir stringers in place, since construction of bridge, all in excellent condition. Treatment approximately 7½ pounds creosote per cubic foot. Hand adzing was done before treatment. Photographed May 24, 1928.

No. 13. C. R. I. & P. bridge 905, between Haskell and Eldorado, Ark., constructed 1914. Four-inch guard rails bolted to ties. Photographed May 24, 1928.



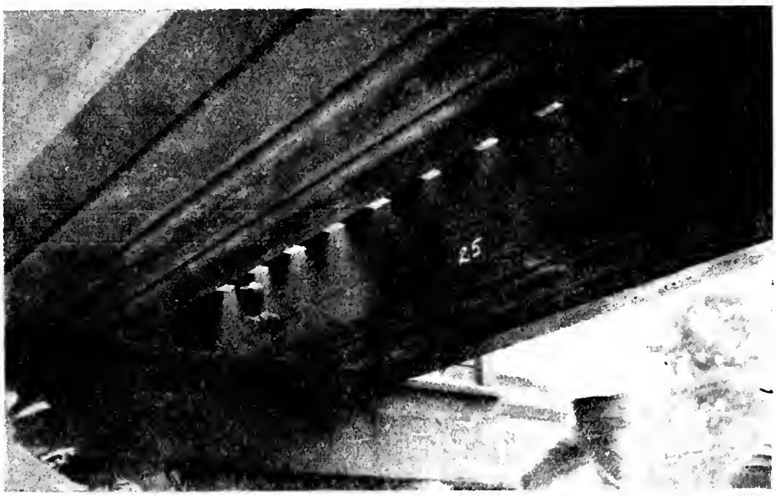
No. 18. C. R. I. & P. bridge 938, Haskell to Eldorado, Ark., constructed 1914. This bridge contains six creosoted Douglas fir stringers per panel, treated with approximately 7½ pounds of creosote per cubic foot. Two additional creosoted pine stringers added later. Piling, caps and bridge ties creosoted southern yellow pine. Photographed May 24, 1928.



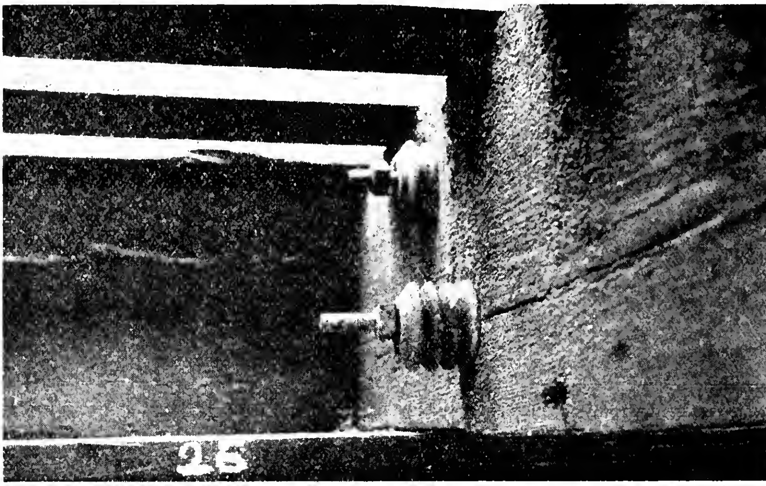
No. 19. C. R. I. & P. bridge 938, Haskell to Eldorado, Ark., constructed 1914, showing under side of creosoted fir stringers all in excellent condition and apparently good for many years additional service. Hand adzing done before treatment. Two outside stringers, creosoted pine, added later. Photographed May 24, 1928.

No. 20. C. R. I. & P. bridge 938, Haskell to Eldorado, Ark., constructed 1914, showing creosoted ties and 4-inch guard rails. Ties are spaced with creosoted wooden spacing blocks. Photographed May 24, 1928.

No. 24. C. R. I. & P. bridge 962, Haskell to Eldorado, Ark., constructed 1914. Six creosoted Douglas fir stringers per panel, treated with approximately 7½ pounds creosote per cubic foot. Two outside stringers, creosoted southern pine applied later. Bridge ties, guard rails, caps and piling all of creosoted southern pine. All in excellent condition and apparently good for many years additional service. Sway braces zinc chloride treated and show decay wherever they come in contact with the ground. Photographed May 24, 1928.



No. 25. C. R. I. & P. bridge 962, Haskell to Eldorado, Ark., constructed 1914. Six inner stringers creosoted Douglas fir treated with approximately 7½ pounds creosote per cubic foot. Two outside stringers, creosoted southern pine, added later. All hand adzing done before treatment. Stringers in excellent condition and apparently good for many years additional service. Caps and piling southern pine. Photographed May 24, 1928.



No. 26. C. R. I. & P. bridge 962, Haskell to Eldorado, Ark., constructed 1914. Showing end bolting of creosoted Douglas fir stringers. Photographed May, 24, 1928.

No. 27. C. R. I. & P. bridge 962, Haskell to Eldorado, Ark., constructed 1914. Showing creosoted bridge ties and four-inch guard rails. Ties spaced with four-inch creosoted spacing blocks. Photographed May 24, 1928.

Picture 43-A. Trestle 45-E, Calistoga Line, Southern Pacific, 195 feet, CSB-4, built 1900 of creosoted Douglas fir. No timbers have been renewed in this bridge as yet. Photographed August 6, 1928.

Picture 44. Trestle 45-E, Calistoga Line, Southern Pacific, 195 feet, CSB-4, built 1900 of creosoted Douglas fir. Close-up of creosoted Douglas fir stringers 12 x 12—30. Note slight crushing of cap above piling. Photographed August 6, 1928.

Picture 45. Trestle 45-E, Calistoga Line, Southern Pacific, 195 feet, CSB-4, built 1900 of creosoted Douglas fir. Close-up of 4-pile bent. Note excellent condition after 28 years' service. Photographed August 6, 1928.

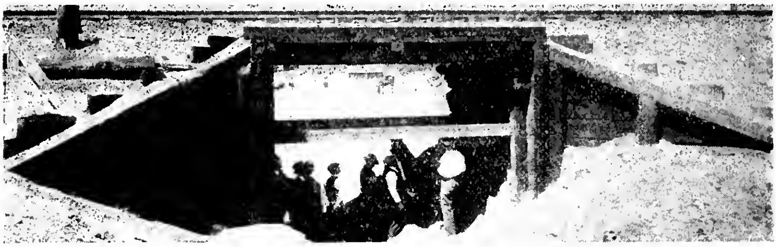
Picture 46. Trestle 45-E, Calistoga Line, Southern Pacific, 195 feet, CSB-4, built 1900 of creosoted Douglas fir. Photographed August 6, 1928.

Picture 59. Creosoted wood stave culvert 56-G, Calistoga Line, Southern Pacific, built 1900 of creosoted Douglas fir. Staves are 4 inches thick—4¾ inches and 5½ inches in width. Borings of staves and timbers of this culvert show sound timber. Culvert braced in middle as shown by photograph, some years after construction account crushing. Photographed August 6, 1928.

Picture 60. Trestle 9-D, Southern Pacific, at Berkeley, Calif., 12 feet, CSB-4, constructed 1897. Entire bridge is as originally constructed except that the sidewalk has been added. Sidewalk is of untreated fir. Photographed August 7, 1928.

Picture 61. Trestle 9-D, Southern Pacific, at Berkeley, Calif., 12 feet, CSB-4, constructed 1897. Close-up of creosoted piling and bulkhead. Photographed August 7, 1928.

Picture 66-A. Increment borer cores taken from creosoted Douglas fir in Bridges 1188-B, A. T. & S. F. near Richmond, constructed 1911; 1188-C, A. T. & S. F. near Richmond, constructed 1915; 9-D, Southern Pacific at Berkeley, constructed 1897; 60-B, Southern Pacific near Tracy, constructed 1900. Borings indicate depth of creosote penetration. Photographed August 7, 1928.

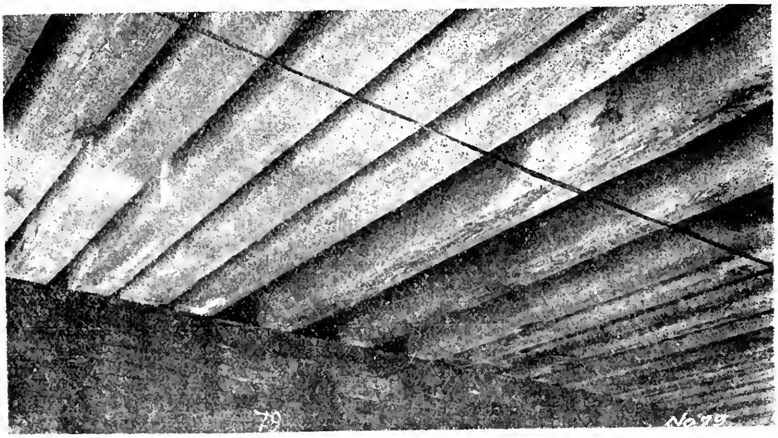


Picture 67. Trestle 55-C, Southern Pacific, Oakland to Tracy, 15 feet, CSB-4, constructed of creosoted Douglas fir in 1896. On account of high bulkheads, necessary to place four 6 x 8 spreaders later. Piles were gained for the spreaders. In 1916 was raised 8 inches and 8 x 12 creosoted fir caps placed on the piles under the original 12 x 12 creosoted caps. Photographed August 7,1928.

Picture 68. Trestle 60-B, Southern Pacific, Oakland to Tracy, 240 feet, CSB-4. Constructed of creosoted Douglas fir 1900. Contains 17 bents, 6 of the bents, 6 piles each, the remainder 4. New caps applied 1927. 12 x 14's laid flat. Some new guard timbers have been applied, replacing original guard timbers broken unloading riprap. Photographed August 7, 1928.

No. 69. Trestle 60-B, Southern Pacific, Oakland to Tracy. Close-up of 6-pile bents. The two outside piles were added in 1923, to eliminate side sway. All of the original 12 x 12 stringers in this bridge still in place. Upon boring into creosoted Douglas fir stringers, some were found with very shallow penetration of creosote, but all were found to be in sound condition. One stringer showed approximately $\frac{1}{8}$-inch penetration. Photographed August 7, 1928.

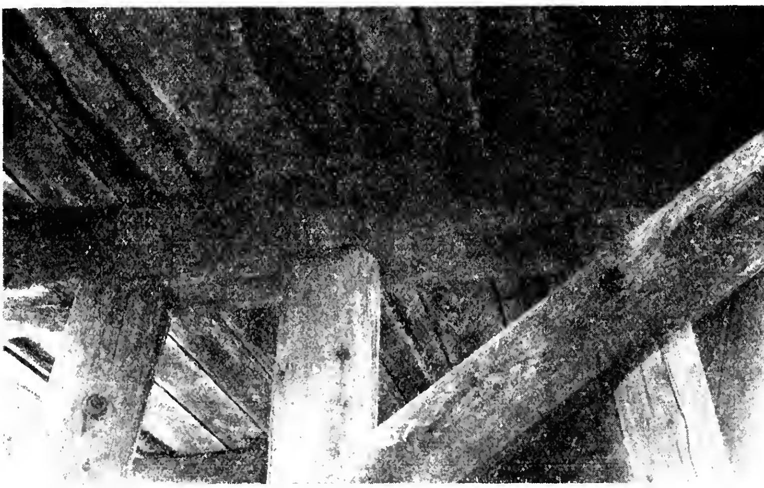
Picture 70. Trestle 60-B, Southern Pacific, Oakland to Tracy. Constructed of creosoted Douglas fir in 1900. Close-up of pile bents. Six bents out of 17 in this trestle are 6-pile bents. The additional piles were added in 1923 to overcome side sway. Photographed August 7, 1928.



Picture 79. Bridge 485-A, Southern Pacific, at Alhambra Avenue, Los Angeles. Eighteen-foot deck of creosoted Douglas fir constructed 1899, 30 7x16 stringers. Creosoted deck supported by two brick piers. Ballast rests on 3-inch creosoted deck plank and the stringers are laid on 7 x 12 creosoted wall plates. No repairs have been made to this structure since constructed. All timbers in sound condition. Photographed August 9, 1928.

Picture 80. Trestle 488-G, Southern Pacific, west of Stoneman, between Los Angeles and Colton, 45 feet, constructed of creosoted Douglas fir in 1901, with 12 x 12 creosoted stringers covered with 3 x 12—14 creosoted fir plank for ballast. These planks were added 1903, three helper bents added 1925, account heavy traffic and are untreated material. New dump bent put in in 1927. Original creosoted timbers in good condition. Photographed August 9, 1928.

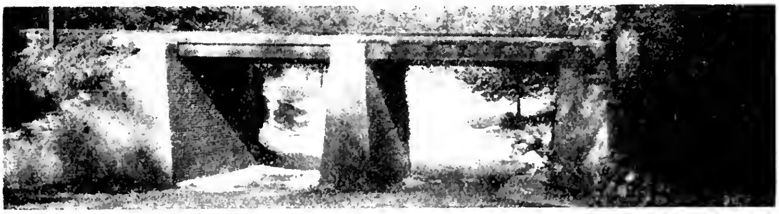
Picture 86. Trestle 507-E, Southern Pacific, east of Walnut. Length, 105 feet. Constructed of creosoted Douglas fir 1901. Eight original bents, four piles to the bent. Helper bents have been added to overcome deflection under heavy power. Four caps have been replaced, two in 1925 and two in 1927. These failed account of crushing over piling. All deck timbers in excellent condition. Photographed August 9, 1928.



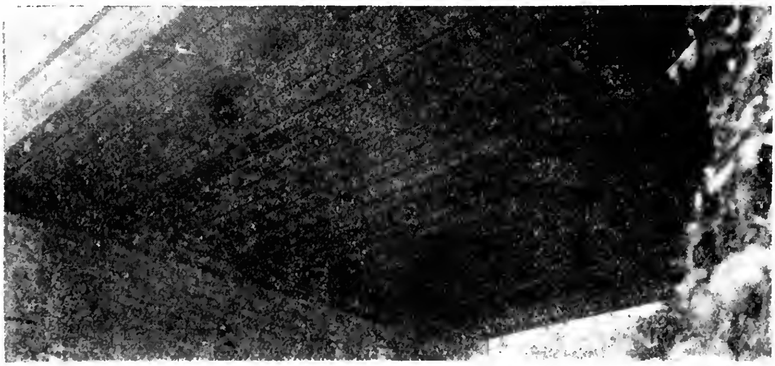
Picture 87. Trestle 507-E, Southern Pacific, east of Walnut. Constructed of creosoted Douglas fir 1900. All deck timbers in excellent condition. Photographed August 9, 1928.

Picture 88. Bridge 513-K, Southern Pacific, on the Covina Branch, Genesha Park, Pomona, Calif. Constructed 1896. Creosoted Douglas fir stringers resting on brick piers. Two 17-foot spans each having 21 7 x 16—18's all in absolutely sound condition. Ends of stringers bear on creosoted 6 x 12's which in turn rest on the brick. Photographed August 9, 1928.

Picture 89. Bridge 513-K, Southern Pacific, Genesha Park, Pomona, Calif. This bridge has two 17-foot spans, each with 21 7 x 16—18 creosoted fir stringers which have been in service since 1896. All in excellent condition. Photographed August 9, 1928.

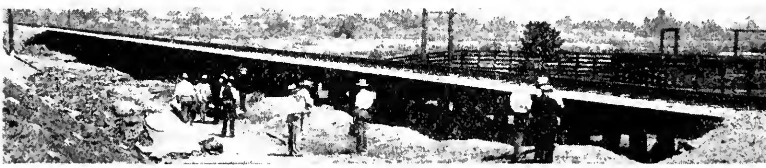


Picture 90. Bridge 513-J, Southern Pacific, Covina Branch, Genesha Park, Pomona, Calif. One 19-foot span contains 29 7 x 16—20's and one 17-foot span contains 21 7 x 16—18 creosoted fir stringers placed in 1896. All in sound condition. Photographed August 9, 1928.

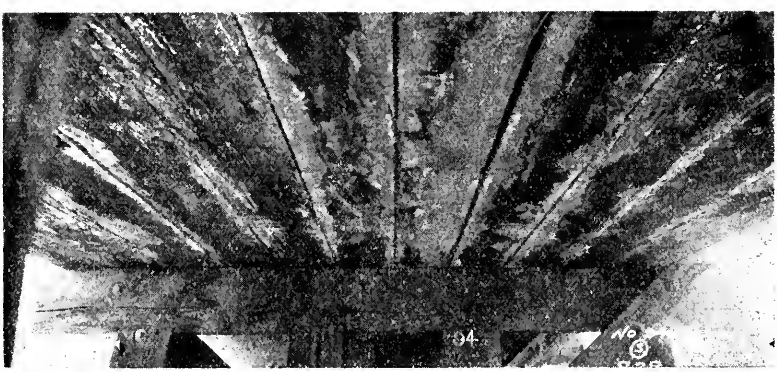


Picture 91. Bridge 513-J, Southern Pacific, Covina Branch, Genesha Park, Pomona, Calif. Close-up of creosoted fir stringers placed in this bridge in 1896, still in excellent condition. This bridge has one 19-foot span with 29 7 x 16—20's and one 17-foot span with 21 7 x 16—18 stringers. Ends of the stringers rest on creosoted 6 x 12's. Photographed August 9, 1928.

Picture 92. Trestle 468-A, Southern Pacific, east of Tejunga. Length, 75 feet, constructed of creosoted Douglas fir 1898. Six bents of four piles each. Two piles renewed in 1919. Also four caps have been renewed. Caps crushing under the head of the piles. Stringers are 12 x 12 laid solid. All timbers sound. Photographed August 10, 1928.

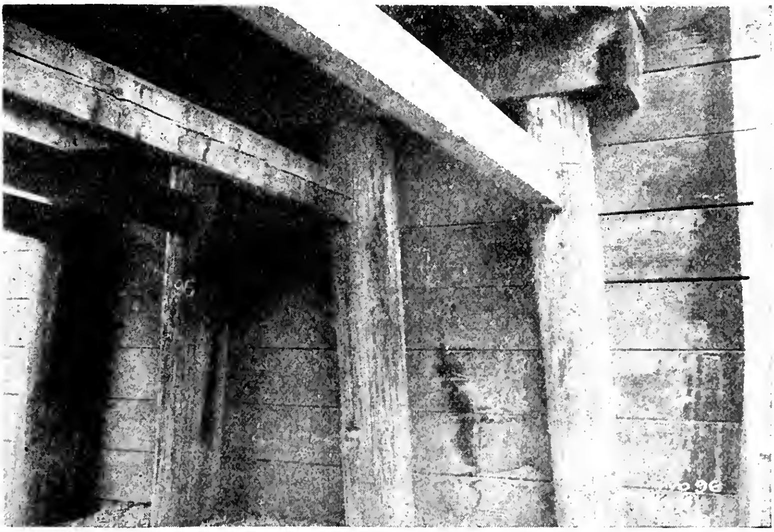


Picture 93. Trestle 462-A, Southern Pacific, east of Fernando. Length, 360 feet. Creosoted Douglas fir, built 1897. Bents have concrete footings with creosoted fir sills anchored to the concrete. All timbers framed before treating. This type of construction was necessary on account of impossibility of driving piling through gravel and rock. Caps have generally been replaced. One decayed sway-brace noted. Caps replaced on account of crushing. Photographed August 10, 1928.

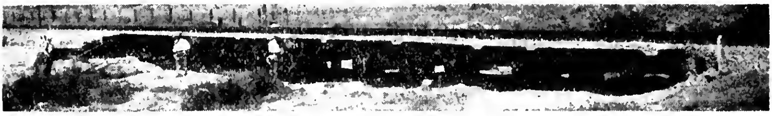


Picture 94. Trestle 462-A, Southern Pacific, east of Fernando. Length 360 feet, creosoted Douglas fir, built 1897. 12 x 12 creosoted Douglas fir stringers good condition. All original caps have been renewed. Of the original posts in the frame bents 16 per cent had been renewed account decay in 1927 at time of washout. Photographed August 10, 1928.

Picture 95. Bridge 460-A, Southern Pacific, east of Sylmar. Length 15 feet, constructed of creosoted Douglas fir 1897. No replacements of original timbers made. Creosoted timber spreaders put in in recent years. All timbers in excellent condition. Photographed August 10, 1928.



Picture 96. Bridge 460-A, Southern Pacific, east of Sylmar. Length, 15 feet, creosoted Douglas fir, constructed 1897. Close-up of piling which were found, on boring, to be in sound condition. Photographed August 10, 1928.

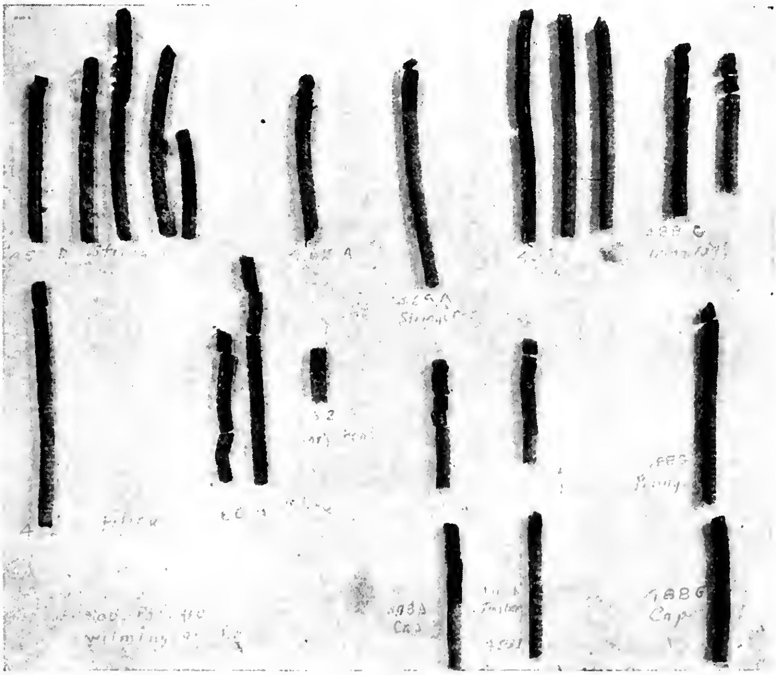


Picture 98. Trestle 451-B, Southern Pacific, east of Saugus. Length, 90 feet, constructed of creosoted Douglas fir 1897. Stringers are 12 x 12 solid type construction, seven bents of four piles each. Five of the piling have been renewed. Helpers have been placed in the bents to take care of heavy traffic. Four caps replaced account of crushing. Photographed August 10, 1928.

Picture 99. Trestle 451-B, Southern Pacific, east of Saugus. Creosoted Douglas fir, constructed 1897. Close-up of cap showing crushing over pile. These were originally four-pile bents. Helpers placed in recent years account heavy traffic. Photographed August 10, 1928.

Picture 100. Trestle 451-B, Southern Pacific, east of Saugus. Creosoted Douglas fir, constructed 1897. Close-up of cap showing crushing over pile. These were originally four-pile bents. Helpers placed in recent years account heavy traffic. Photographed August 10, 1928.

Picture 120. Increment borings from Southern Pacific Bridges 53-D, constructed 1901; 56-G (wood stave culvert) constructed 1900; 60-A, constructed 1900, and 69-B, constructed 1900, indicating penetration of creosote in Douglas fir timber. Also sound condition of timber after 27 and 28 years in service. Photographed August 6, 1928.



Picture 122. Increment auger cores from creosoted Douglas fir, Southern Pacific Bridges 452-D, constructed 1897; 460-A, constructed 1897; 462-A, constructed 1897; 468-A, constructed 1898; 493-I, constructed 1901, and 488-G, constructed 1901, all showing timbers in sound condition and indicating depth of penetration of the creosote.

Picture 123. Increment auger cores from creosoted Douglas fir, Southern Pacific Bridges 498-B, constructed 1896; 506-B, constructed in 1898; 504-B, constructed 1901, and 451-B constructed 1897, all showing sound condition of the timber and indicating the depth of the creosote.

REPORT OF COMMITTEE XXI — ECONOMICS OF RAILWAY OPERATION

JAMES M. FARRIN, *Chairman;*	J. E. TEAL, *Vice-Chairman;*
B. T. ANDERSON,	R. J. MIDDLETON,
G. D. BROOKE,	F. H. MCGUIGAN, JR.,
A. C. BRADLEY,	H. T. PORTER,
J. M. BROWN,	L. H. POWELL,
M. L. BYERS,	J. F. PRINGLE,
S. B. COOPER,	L. S. ROSE,
H. C. CROWELL,	J. E. SAUNDERS,
W. J. CUNNINGHAM,	MOTT SAWYER,
L. E. DALE,	R. T. SCHOLES,
OLIVE W. DENNIS,	B. J. SCHWENDT,
G. F. HAND,	V. I. SMART,
G. W. HAND,	C. H. STEIN,
E. M. HASTINGS,	M. F. STEINBERGER,
E. E. KIMBALL,	F. L. THOMPSON,
L. E. LITTLE,	BARTON WHEELWRIGHT,
T. C. MACNABB,	C. C. WILLIAMS,
M. F. MANNION,	*Committee.*

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

1. Revision of the Manual. No revisions are recommended.

2. Continue the study of methods for obtaining a more intensive use of existing railway facilities, with particular reference to increasing carrying capacity:

   (a) Without material capital expenditures.
   (b) With due regard to reasonable capital expenditures consistent with traffic requirements (Appendix A).

3. Continue the study of methods or formulas for the solution of special problems relating to more economical and efficient railway operation (Appendix B).

4. Continue the study of the most economical make-up of track to carry various traffic densities, collaborating with Committee IV—Rail (Appendix C).

5. Continue the study of suitable units for operating and equipment statistics required by Interstate Commerce Commission to be used in cost comparisons of transportation, equipment and roadway maintenance, with necessary additions thereto, collaborating with Committee XI—Records and Accounts, and Committee XXII—Economics of Railway Labor (Appendix D).

6. Continue the study of what volume or other conditions of business or service justifies a change from flat switching to the hump method in any given yard, collaborating with Committee XIV—Yards and Terminals (Appendix E).

Bulletin 313, January, 1929.

7. Continue the study of problems of railway operation as affected by the introduction of motor trucks and bus lines, with particular reference to its effect upon branch or feeder lines, collaborating with Motor Transport Division, American Railway Association (Appendix F).

8. Study and develop most economical train length, considering all factors entering into transportation costs such as fuel, road time, length of passing sidings, per diem, etc. (Appendix G).

9. Study economics resulting from use of Radio Telephones for long freight trains and for yard work.

10. Outline of work for ensuing year.

Action Recommended

1. No revision of the Manual recommended.

2. That the progress report of Sub-Committee (Appendix A) be received as a method of arriving at and example of operation economies realized both with and without capital expenditure.

3. That report of the Sub-Committee (Appendix B) be received as information and special subject studied further next year.

4. That report of the Sub-Committee (Appendix C) be received as information and work on this subject held in abeyance until similar subject which was assigned to the Rail Committee has been reported upon.

5. That report of the Sub-Committee (Appendix D) be received as a progress report and subject reassigned.

6. That report of the Sub-Committee (Appendix E) be received as information and subject reassigned.

7. That report of the Sub-Committee (Appendix F) be received as information and subject reassigned.

8. That report of the Sub-Committee (Appendix A) be received as final and subject dropped.

9. That report of the Sub-Committee (Appendix F) be received as a progress report and subject reassigned.

Recommendations for Future Work

That same subjects be reassigned as stated above under "Action Recommended."

Respectfully submitted,

THE COMMITTEE ON ECONOMICS OF RAILWAY OPERATION,

JAMES M. FARRIN, *Chairman.*

Appendix A

(2) STUDY OF METHODS FOR OBTAINING A MORE INTENSIVE USE OF EXISTING RAILWAY FACILITIES, WITH PARTICULAR REFERENCE TO INCREASING CARRYING CAPACITY:

(a) Without Material Additional Capital Expenditures.
(b) With Due Regard to Reasonable Increases in Capital Expenditures Consistent with Traffic Requirements.

M. F. Mannion, Chairman, Sub-Committee; B. T. Anderson, S. B. Cooper, Olive W. Dennis, J. M. Farrin, G. W. Hand, E. F. Hastings, E. E. Kimball, J. F. Pringle, L. S. Rose, J. E. Saunders, Mott Sawyer, B. J. Schwendt, C. H. Stein, V. I. Smart, H. Stringfellow, R. T. Scholes, J. E. Teal.

HISTORY

Thus far the Committee has investigated the following:

(1) The effect of the number of trains per day.
(2) The effect of the length of engine district.
(3) The effect of double-tracking.
(4) The effect of passenger train operation upon freight train performance.
(5) The effect of supervision.
(6) The effect of substituting heavy steam power for light.
(7) The effect of installing automatic signals.

Two subjects which fall within the scope of this assignment have been studied this year, namely:

Study and develop methods for determining most economical train lengths considering all factors entering into transportation costs, such as fuel, road time, length of passing sidings, per diem, etc.

Study effects of improvement made on a heavy traffic North and South Railroad.

On account of the technical character of these studies they are presented as Exhibits A and B. Those interested in making similar investigations on other roads will find these studies helpful guides in planning their work.

This year the Committee also desires to call attention to a factor in railway operation which, considering its importance, has had little recognition in these studies, namely, improved service. This is a matter which is extremely difficult to capitalize, but traffic departments are interested in developments along this line on account of the bearing which the service has in securing new business or maintaining tariffs. The service which a railroad furnishes reaches out in so many directions that it is difficult to estimate how it reacts upon other conditions affecting railway operation and for this reason it seems a proper subject to be discussed by this Committee.

An analysis of statistics regarding Class I roads in the United States, published by the Interstate Commerce Commission discloses some noteworthy accomplishments obtained by the railways during the past seven years.

Table I—Statistics of Railways in the United States

Year	1000 Freight Train Miles	Million Gross Ton Miles Excl. Loco.	Train Hour	1000 Freight Train-Miles Per Day	Million Gross Ton-Miles Per Day	Hours Per 100 Train-Miles
1921	530,141	760,716	45,949,610	1,452	2,084	8.67
1922	554,780	813,052	50,148,349	1,520	2,227	9.04
1923	641,556	987,384	58,885,148	1,758	2,705	9.18
1924	600,576	953,968	52,239,512	1,640	2,605	8.71
1925	612,865	1,023,490	52,010,380	1,679	2,805	8.49
1926	632,557	1,098,692	53,064,819	1,733	3,010	8.39
1927	610,497	1,086,829	49,525,815	1,673	2,978	8.11

From the above table Class I railways in the United States during the year 1921 operated a total of 530,141 thousand freight train-miles which is equivalent to 1452 thousand freight train-miles per day. The gross ton-miles moved is equivalent to hauling 760,716 million tons one mile or 2084 million ton-miles per day. The freight train-hours required to handle this traffic amounted to 45,949,610 which is equivalent to 8.67 hours per 100 freight train-miles.

During the year 1926, or five years later, Class I roads averaged 1733 thousand train-miles per day, or an increase of 19.4 per cent, and handled an average of 3010 million gross ton-miles per day, an increase of 44.4 per cent. The average road time per 100 freight train-miles was decreased from 8.67 hours in 1921 to 8.39 hours in 1926.

Briefly summarized it can be stated that railways handled 44.4 per cent more freight traffic in 1926 than in 1921, operated 19.4 per cent more freight train-miles and improved the road time .28 hours per 100 freight train-miles.

A somewhat better picture may be obtained from the statistics shown in the above table if a comparative freight train performance chart is constructed as shown in Fig. 1 by plotting the data shown in the last three columns. It is customary to show these charts in two parts, the upper part being constructed by plotting the number of train-miles per day against the hours per 100 train-miles and the lower part by plotting the number of gross ton-miles per day against the hours per 100 train-miles.

Thus in the upper chart the average performance and corresponding number of train-miles per day are represented by dots which are numbered to correspond to the respective years. Likewise, in the lower diagram the dots represent the average performance when referred to the number of gross ton-miles per day. The sloping lines marked "Average Road Time 1921 and 1926" are drawn through a common point on the horizontal axis and the dots numbered 1921 and 1926, respectively. The manner in which the common point on the horizontal axis is determined is by means of monthly performance charts described in previous reports.

COMPARATIVE FREIGHT TRAIN PERFORMANCE—RAILWAYS IN THE UNITED STATES—ALL DISTRICTS

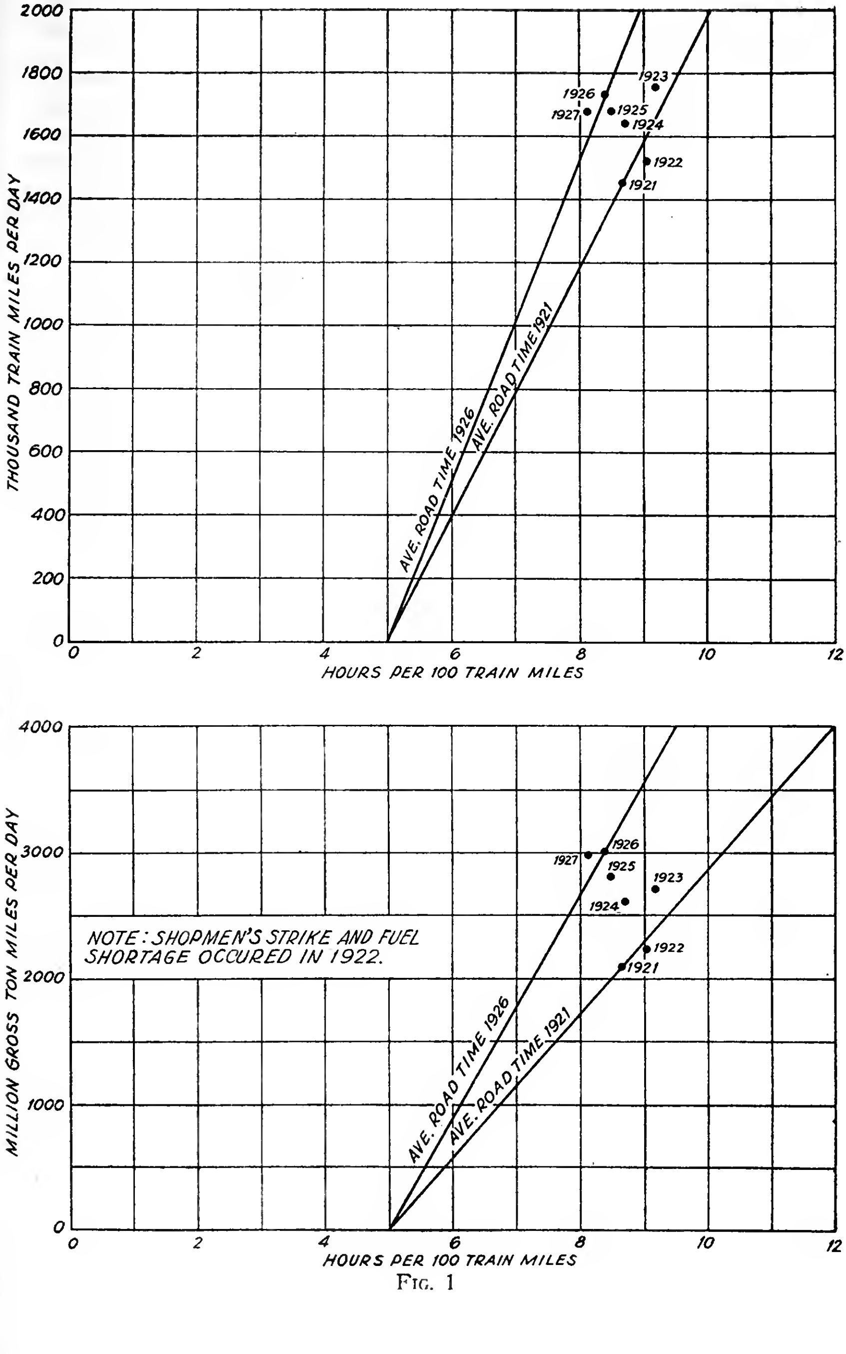


FIG. 1

From inspection of these charts it will be seen that all of the dots except those for 1922 and 1927 lie on or between the two sloping lines. Were it not for the shopmen's strike which started July, 1922, and the fuel shortage resulting from the strike of union miners in the spring of the same year it is probable that the dot for 1922 would also have been between the two sloping lines. It will also be seen that if similar lines are drawn through the dots for 1923 that the dots for 1924 and 1925 will be above these lines and likewise the dots for 1925 are above similar lines drawn through the 1924 dots. In other words, each year shows an improvement in performance over the previous year. The performance for 1927 shows an improvement over that for 1926 although there was less traffic handled in 1927 than in 1926.

The horizontal distance between the two sloping lines in the lower chart for the same traffic handled represents the improvement which would have been made in the average road time per 100 train-miles between 1921 and 1926. That is, if there had been no increase in traffic between 1921 and 1926 the railways would have been able to reduce the average road time 1.32 hours per 100 train miles (from 8.67 to 7.35 hours). In addition they would have been able to handle the traffic with 82.7 per cent of the train-miles (1200 thousand train-miles per day on the 1926 line in the upper chart corresponding to 7.35 hours instead of 1452 thousand train-miles on the 1921 line corresponding to 8.67 hours). In other words, with the smaller number of train-miles and shorter time there would have been a saving of nearly 14,000,000 train-hours per year.

The vertical distance between the two sloping lines in the lower chart represents the increase in capacity provided by the railways between 1921 and 1926. It amounts to more than 56 per cent, whereas the railways only secured 44.4 per cent more traffic than they handled in 1921. During 1926 the railways provided still more capacity expecting the traffic to increase in 1927. Instead the traffic fell off and had not caught up during the first ten months of 1928. The service nevertheless improved during 1927 and records for ten months of 1928 show a further improvement over last year. With the improvements made in 1927 it is safe to state that during the seven years between 1921 and 1928, the railways in the United States have increased in capacity 80 per cent, whereas the traffic handled has increased only 45 per cent. No doubt trade conditions throughout the country are responsible for the falling off of traffic since 1926. With better conditions it can be expected that the traffic will increase, but in the meantime the railways have established a record for service which is not generally appreciated.

The railways have accomplished these results in two ways:

(1) Through effective management.

(2) By the installation of new and greater facilities.

In regard to the first, it will be remembered that the year 1921 was the first complete year the railways were operated by corporate management since the United States Railroad Administration took them over in 1918.

The performance for 1921 therefore reflects conditions existing during a period of readjustment when it was impossible to secure the same co-operative spirit which now exists between the management and the men. This is only one example where the management has been effective in improving operating conditions. Other instances of more importance may be mentioned, but they may be regarded as factors which are gradually changing from year to year. The improvement in morale was an almost abrupt change which probably will not have a counterpart in the future. It is difficult to estimate to what extent this change is responsible for the improvement in train performance, but judging from the fact that there has been an 80 per cent increase in capacity and only 45 per cent increase in traffic it would seem that the railways are justified in assuming that 20 per cent may be due to this cause.

In regard to the installation of new and greater facilities, the reports of the Interstate Commerce Commission show that during the five years 1921-1925, inclusive, the railways invested $3,890,000,000 for new facilities and retired facilities amounting to $984,000,000 leaving a net investment of $2,906,000,000, which was distributed as shown in the following table. New capital in large amounts is still being invested in the railways. During 1926 new facilities representing an investment of $870,000,000 were provided and existing facilities valued at $218,000,000 were retired, leaving a net investment of $652,000,000 for the year.

Table II—Railways in the United States

Net Charges to Investment in Road and Equipment Year 1926 Compared with 5-Year Periods 1921-1925, Inclusive, All Districts

Road	*Total 5-Year Period 1921-25, Incl.*	*Average 5-Year Period 1921-25, Incl.*	*Year 1926*
Roadway and Track	$1,053,000,000	$211,000,000	$334,000,000
Structures	166,000,000	33,000,000	38,000,000
Steam Accessories	215,000,000	43,000,000	50,000,000
Electric Accessories	25,000,000	5,000,000	11,000,000
Communication	64,000,000	13,000,000	33,000,000
Miscellaneous	Cr. 79,000,000	Cr. 16,000,000	Cr. 50,000,000
Total Road	$1,450,000,000	$290,000,000	$416,000,000
Equipment			
Steam Power	$ 380,000,000	$ 76,000,000	$ 73,000,000
Electric Power	20,000,000	4,000,000	14,000,000
Rolling Stock	980,000,000	196,000,000	135,000,000
Miscellaneous	55,000,000	11,000,000	11,000,000
Total Equipment	$1,435,000,000	$287,000,000	$233,000,000
General			
Total General	$ 21,000,000	$ 4,000,000	$ 3,000,000
Grand Total	$2,906,000,000	$581,000,000	$652,000,000

A

On account of the fact that the traffic has fallen off in 1927 and 1928 the investments made in 1926 and 1927 have not thus far resulted in any additional traffic or increased revenues for the railways. They have, however, resulted in a better service not only as regards time on the road but in many other ways, all branches of railway organization contributing their part. Directly and indirectly the public benefits through these expenditures and in turn benefits accrue to the railroads. Consequently, the growth of railways is in cycles, part of the time railway investments are in anticipation of increased traffic and part of the time they lag behind waiting for the traffic to build up. For this reason and because of the magnitude of the expenditures involved, it is necessary to have a background of related facts in order to forecast the future and study ways and means for obtaining more intensive use of facilities already provided or which may be provided. Freight train performance charts illustrated in Fig. 1 have been developed for this purpose. Some of their uses have been described in previous reports, but it is believed that their application is not generally understood.

Exhibit A has been arranged primarily as an example to be used for reference and to illustrate how the train-hour diagrams and freight-train performance charts may be used to bring out some of the fundamental factors which have to do with train operation. When these train performance studies are completed, the facts are all assembled, the proper remedies can be applied as conditions warrant.

Exhibit A

METHOD FOR DETERMINING MOST ECONOMICAL TRAIN LENGTHS, CONSIDERING ALL FACTORS ENTERING INTO TRANSPORTATION COSTS SUCH AS FUEL, ROAD TIME, LENGTH OF PASSING SIDINGS, PER DIEM, ETC.

Data for making this study was obtained from a road in the Western District consisting of seven operating districts. A condensed profile and track chart of one of the districts is shown in Fig. 2. For the most part the road traverses a rolling country calling for grades of .5 per cent or less. Near the north end there is a grade equivalent to 1.52 per cent ruling which requires helper service for a distance of nearly six miles. The procedure proposed is as follows:

1. Determine the track capacity for the given arrangement of tracks.
2. Determine capacity of locomotives.
3. Show how track and locomotive capacities combine.
4. Simplify train-hour diagrams by constructing the corresponding freight train performance charts.
5. Determine the weight of train which will give the best performance.
6. Compare performance with available track capacity.
7. Compare performance with number of locomotives required.
8. Compare performance with locomotive maintenance.
9. Compare performance with fuel consumption.
10. Compare performance with crew expense.
11. Compare performance with other items of expense.

1. Determine the Track Capacity for the Given Arrangement of Tracks

Between the terminal yards there are 25 passing sidings and one intermediate yard in a distance of 122.4 miles. The total amount of track in passing sidings amounts to about 20 miles or about one-sixth of the main track mileage. The average length of sidings is about 4000 feet and the shortest siding is 2757 feet or long enough for a train of about 50 cars.

Considering a passing siding and an adjacent section of single track as a unit it will be seen that there are 27 units including the intermediate yard in the 122.4 miles, or the average length of a unit is 4.5 miles. The length of the maximum unit is 6.6 miles. Theoretically when sidings are uniformly spaced so that meets will come at regular intervals, the track capacity measured in train-hours per day is equal to 24 $\times$ the number of single track sections between terminals. In this case it would be $24 \times 27 = 648$ train hours per day if the sidings were spaced equal time intervals apart corresponding to an average of 4.5 miles. When the sidings are not uniformly spaced the track capacity is no greater than if the sidings were spaced at time intervals corresponding to the longest unit, in this case 6.6 miles. On this basis the corrected track capacity is not greater than

$$24 \times \frac{122.4}{6.6} = 24 \times 19 = 456 \text{ train-hours per day.}$$

There are four passenger trains per day operated over this district and during the heaviest traffic months there are nearly ten freight trains per day. The four passenger trains will average 3.75 hours on the road and the freight trains about 8.5 hours making a total of about 100 train-hours for both services indicating that only about 20 per cent of the theoretical track capacity is being utilized.

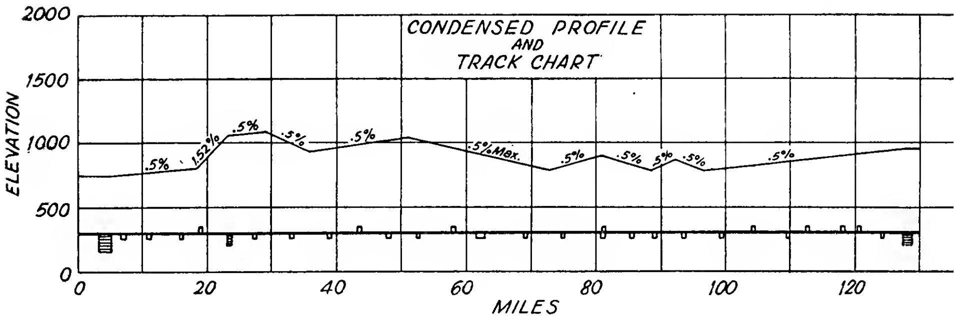


FIG. 2

2. Determine Capacity of Locomotives

In order that this study may contain data which can be used for other conditions, a table has been prepared showing the grades on which various weights of train expressed in terms of total weight of locomotive including tender can be hauled. The weight on drivers of steam locomotives in freight service will generally be between 50 and 60 per cent of the total weight of the locomotives and tender in working order. If it is assumed, for example, that the tractive effort rating of a locomotive can be safely based upon 20 per cent of the weight on drivers then the tractive effort per ton on drivers, which the locomotive can exert without slipping its wheels, will be $.20 \times 2000 = 400$ lb. If the weight on drivers is equal to half the total weight of the locomotive and tender then the tractive effort per ton total weight of locomotive will be $\frac{1}{2} \times 400 = 200$ lb. When the locomotive is pulling a train five times its weight the total train weight, including the locomotive, is six times the locomotive weight, hence the tractive effort per ton of total train will be $\frac{1}{6} \times 200 = 33.3$ lb. Subtracting train and curve resistance assumed at 6 lb. per ton from 33.3 will leave 27.3 lb. per ton which is available for accelerating the train or for overcoming grades. It requires 20 lb. per ton to overcome a 1 per cent grade hence the maximum grade such a locomotive can climb with a train five times its weight is $\frac{27.5}{20} = 1.38$ per cent assuming a coefficient of adhesion between the rim of the drivers and top of the rails of 20 per cent.

If the weight on drivers is more than half the total weight of locomotive and tender, say 60 per cent, then by substitution, the maximum grade becomes $\frac{34}{20} = 1.7$ per cent rail conditions remaining the same as above.

Frequently rail conditions are better than assumed, that is, the drivers might not slip when the locomotive is exerting a tractive effort equal to 25 per cent of the weight on the drivers. Under these conditions the locomotives may also be able to start the trains on the maximum grades determined above.

The following table is divided into two parts, the grades shown in the first part are estimated to be the maximum grades the locomotive can start a train on under good rail conditions. The grade shown in the second part are estimated to be the maximum grades the locomotive will not stall on under good rail conditions if up to speed. For design purposes a margin of safety should be applied to both tables.

Table III—Showing Maximum Grades Negotiable by Freight Locomotives with Various Weight Trains

Based on 20 Per Cent Coefficient of Adhesion

A—Weight on drivers equals 50 per cent total weight of locomotive including tender.
B—Weight on drivers equals 60 per cent total weight of locomotive including tender.

	Maximum Grade Per Cent A	Maximum Grade Per Cent B
Weight of train equals 5.0 times locomotive weight including tender..	1.38	1.70
Weight of train equals 7.5 times locomotive weight including tender..	.88	1.12
Weight of train equals 9.0 times locomotive weight including tender..	.70	.90
Weight of train equals 11.0 times locomotive weight including tender..	.53	.70
Weight of train equals 14.0 times locomotive weight including tender..	.37	.50
Weight of train equals 18.0 times locomotive weight including tender..	.23	.33
Based on 25 Per Cent Coefficient of Adhesion		
Weight of train equals 5.0 times locomotive weight including tender..	1.79	2.20
Weight of train equals 7.5 times locomotive weight including tender..	1.17	1.46
Weight of train equals 9.0 times locomotive weight including tender..	.95	1.20
Weight of train equals 11.0 times locomotive weight including tender..	.74	.95
Weight of train equals 14.0 times locomotive weight including tender..	.53	.70
Weight of train equals 18.0 times locomotive weight including tender..	.36	.49

The next step in determining the capacity of locomotives is to consider the speed which the locomotives will make with these various weight trains on various grades when obliged to stop at varying intervals. The following table contains the estimated average running speeds of freight trains under a variety of these conditions.

Not all freight locomotives now operating are capable of making the speeds shown for the various weight trains and probably some of the modern locomotives will do better. A great deal depends upon the condition of the locomotives and the performance of the crews. The values given in the table are based upon average conditions including temperature and weather, mechanical condition of the equipment, usual assortment of empty and loaded cars and the ability of crews in handling trains. In some cases it will be necessary to apply correction factors depending upon the kind of studies being made. When conditions warrant tests may be required to verify the estimated values.

The table is divided into groups each group representing a different combination of train and locomotive weights. Thus the average running speeds given in Group I pertain to a combination of train and locomotive

TABLE IV. — SHOWING AVERAGE RUNNING SPEED AND RELATIVE FUEL CONSUMPTION PER HOUR FOR VARIOUS WEIGHTS OF FREIGHT TRAINS AND FOR VARIOUS LENGTHS OF RUNS, DURATION OF STOPS AND FUEL CONSUMPTION DURING STOPS NOT INCLUDED

	MILES BETWEEN STOPS										FREE RUNNING SPEED	
	1		2		5		10		20			
Grade	Fuel	M.P.H.	Fuel	M.P.H.	Fuel	M.P.H.	Fuel	M.P.H.	Fuel	M.P.H.	Fuel	M.P.H.
Group I Relative Trailing Weight 1.00 = 5 x wt. of loco.												
-.6%	1.000	18.8	1.000	25.4	.708	35.9	.464	41.8	.310	45.6	ϕ.125	*50.0
-.4%	1.000	18.0	1.000	24.3	.816	34.6	.564	41.0	.400	45.0	.200	*50.0
-.2%	1.000	17.2	1.000	22.9	.985	32.5	.836	39.5	.733	44.0	.600	*50.0
-.6%	1.000	18.8	.863	25.2	.504	32.4	.324	35.8	.236	37.8	ϕ.125	*40.0
-.4%	1.000	18.0	.938	24.3	.551	31.8	.362	35.4	.251	37.6	ϕ.125	*40.0
-.2%	1.000	17.2	1.000	22.9	.788	30.8	.683	34.8	.612	37.2	.530	*40.0
-.6%	1.000	18.8	.719	24.4	.416	29.8	.282	32.2	.207	33.6	ϕ.125	*35.0
-.4%	1.000	18.0	.776	23.7	.448	29.4	.300	32.0	.217	33.4	ϕ.125	*35.0
-.2%	1.000	17.2	.921	22.8	.711	29.0	.614	31.6	.513	33.2	.497	*35.0
LEVEL	1.000	16.2	1.000	21.4	1.000	29.7	1.000	36.0	1.000	41.3	1.000	50.0
+.2%	1.000	15.3	1.000	19.5	1.000	26.2	1.000	30.6	1.000	33.8	1.000	38.0
+.4%	1.000	14.2	1.000	18.0	1.000	22.7	1.000	25.3	1.000	26.8	1.000	28.5
+.6%	1.000	12.8	1.000	15.8	1.000	18.8	1.000	20.0	1.000	20.8	1.000	21.6
+.8%	1.000	11.4	1.000	13.7	1.000	15.6	1.000	16.4	1.000	16.8	1.000	17.2
+1.0%	1.000	9.7	1.000	11.5	1.000	12.9	1.000	13.4	1.000	13.7	1.000	14.0
+1.2%	1.000	9.3	1.000	10.3	1.000	11.1	1.000	11.3	1.000	11.4	1.000	11.6
Group II Relative Trailing Weight 1.50 = 7.5 x wt. of loco.												
-.6%	1.000	17.4	1.000	23.8	.788	34.0	.519	40.7	.398	45.0	ϕ.125	*50.0
-.4%	1.000	16.6	1.000	22.2	.960	32.0	.651	39.1	.447	44.0	.200	*50.0
-.2%	1.000	15.5	1.000	20.5	1.000	29.2	.968	36.2	.812	41.8	.600	*50.0
-.6%	1.000	17.4	.944	23.7	.558	31.4	.368	35.2	.254	37.4	ϕ.125	*40.0
-.4%	1.000	16.6	1.000	22.2	.636	30.3	.416	34.5	.281	37.0	ϕ.125	*40.0
-.2%	1.000	15.5	1.000	20.5	.887	28.7	.737	33.4	.643	36.4	.530	*40.0
-.6%	1.000	17.4	.790	23.2	.460	29.1	.308	31.8	.221	33.3	ϕ.125	*35.0
-.4%	1.000	16.6	.878	22.2	.512	28.4	.339	31.4	.238	33.1	ϕ.125	*35.0
-.2%	1.000	15.5	1.000	20.5	.775	27.4	.653	30.7	.580	32.7	.497	*35.0
LEVEL	1.000	14.5	1.000	19.2	1.000	25.7	1.000	30.7	1.000	34.5	1.000	40.0
+.2%	1.000	12.9	1.000	16.7	1.000	21.4	1.000	24.2	1.000	25.8	1.000	28.0
+.4%	1.000	11.7	1.000	14.0	1.000	16.9	1.000	18.3	1.000	19.1	1.000	20.0
+.6%	1.000	9.5	1.000	11.4	1.000	13.1	1.000	13.8	1.000	14.3	1.000	14.8
+.8%	1.000	8.7	1.000	9.9	1.000	10.8	1.000	11.1	1.000	11.3	1.000	11.5
Group III Relative Trailing Weight 1.80 = 9 x wt. of loco.												
-.6%	1.000	16.8	1.000	22.8	.835	33.1	.553	39.8	.363	44.3	ϕ.125	*50.0
-.4%	1.000	15.4	1.000	21.2	1.000	30.5	.713	37.9	.492	43.1	.200	*50.0
-.2%	1.000	14.6	1.000	19.3	1.000	27.2	1.000	33.8	.980	39.7	.600	*50.0
-.6%	1.000	16.8	.993	22.8	.592	30.7	.389	34.8	.267	37.2	ϕ.125	*40.0
-.4%	1.000	15.4	1.000	21.2	.693	29.4	.452	33.9	.302	36.7	ϕ.125	*40.0
-.2%	1.000	14.6	1.000	19.3	.959	27.1	.786	32.3	.672	35.8	.530	*40.0
-.6%	1.000	16.8	.834	22.5	.478	28.2	.321	31.2	.228	33.0	ϕ.125	*35.0
-.4%	1.000	15.4	.945	21.2	.555	27.8	.365	31.0	.252	32.8	ϕ.125	*35.0
-.2%	1.000	14.6	1.000	19.3	.826	26.3	.685	30.0	.620	32.3	.497	*35.0
LEVEL	1.000	13.4	1.000	17.1	1.000	23.0	1.000	27.2	1.000	30.6	1.000	35.0
+.2%	1.000	11.5	1.000	14.6	1.000	18.4	1.000	20.6	1.000	21.8	1.000	23.3
+.4%	1.000	9.5	1.000	11.8	1.000	14.0	1.000	14.9	1.000	15.5	1.000	16.0
+.6%	1.000	6.5	1.000	8.3	1.000	10.1	1.000	10.9	1.000	11.3	1.000	11.8
Group IV Relative Trailing Weight 2.20 = 11 x Wt. of Loco.												
-.4%	1.000	14.6	1.000	20.0	1.000	29.0	.780	36.6	.535	42.3	.200	*50.0
-.2%	1.000	13.5	1.000	18.0	1.000	25.3	1.000	31.2	1.000	36.7	.575	46.5
-.4%	1.000	14.6	1.000	20.0	.752	28.3	.492	33.1	.326	36.3	ϕ.125	*40.0
-.2%	1.000	13.5	1.000	18.0	1.000	25.3	.859	30.9	.716	34.9	.530	*40.0
-.4%	1.000	14.6	1.000	20.0	.601	26.9	.394	30.4	.269	32.6	ϕ.125	*35.0
-.2%	1.000	13.5	1.000	18.0	.891	25.0	.727	29.2	.623	31.8	.497	*35.0
LEVEL	1.000	11.8	1.000	15.6	1.000	20.7	1.000	24.3	1.000	26.9	1.000	30.0
+.2%	1.000	9.9	1.000	12.7	1.000	15.7	1.000	17.3	1.000	18.1	1.000	19.2
+.4%	1.000	7.1	1.000	9.1	1.000	11.1	1.000	11.9	1.000	12.4	1.000	12.9
Group V Relative Trailing Weight 2.8 = 14 x Wt. of Loco.												
-.4%	1.000	15.7	1.000	18.9	1.000	27.5	.897	35.0	.610	41.2	.200	*50.0
-.4%	1.000	15.7	1.000	18.9	.978	27.2	.546	32.3	.358	35.8	ϕ.125	*40.0
-.2%	1.000	12.5	1.000	16.6	1.000	23.3	1.000	28.5	1.000	33.4	1.000	41.5
-.4%	1.000	15.7	1.000	18.9	.662	26.1	.433	29.9	.291	32.3	ϕ.125	*35.0
-.2%	1.000	12.5	1.000	16.6	1.000	23.3	.805	27.9	.670	31.5	.497	*35.0
-.4%	1.000	15.7	880	18.8	.514	24.3	.340	26.8	.238	28.3	ϕ.125	*30.0
-.2%	1.000	12.5	1.000	16.6	.813	22.6	.661	25.9	.487	27.7	.460	*30.0
LEVEL	1.000	11.0	1.000	14.0	1.000	18.3	1.000	21.0	1.000	22.8	1.000	25.0
+.2%	1.000	7.8	1.000	10.0	1.000	12.4	1.000	13.6	1.000	14.3	1.000	15.0
+.4%	1.000	5.6	1.000	7.2	1.000	8.7	1.000	9.3	1.000	9.6	1.000	10.0
Group VI Relative Trailing Weight 3.6 = 18 x wt. of Loco.												
-.4%	1.000	13.0	1.000	17.6	1.000	25.8	1.000	32.8	.700	39.7	.200	*50.0
-.4%	1.000	13.0	1.000	17.6	.933	25.6	.618	31.2	.402	35.1	ϕ .125	*40.0
-.4%	1.000	13.0	1.000	17.6	.727	25.0	.476	29.1	.317	31.8	ϕ .125	*35.0
-.2%	1.000	11.1	1.000	15.5	1.000	20.8	1.000	25.3	1.000	29.9	1.000	36.5
-.4%	1.000	13.0	.740	17.0	.429	21.1	.290	22.9	.211	23.9	ϕ .125	*25.0
-.2%	1.000	11.1	1.000	15.0	.733	19.7	.595	22.0	.513	23.4	.421	*25.0
LEVEL	1.000	8.8	1.000	11.5	1.000	15.0	1.000	17.2	1.000	18.5	1.000	20.0
+.2%	1.000	4.3	1.000	6.0	1.000	8.4	1.000	9.6	1.000	10.4	1.000	11.3

* Speed limited.
ϕ Stand by losses.

weights such that the free running speed on level track will be 50 m.p.h. Assume that the trailing weight of this combination is given a weight of unity, then it will be found that the same locomotive will haul a 50 per cent heavier train at 40 m.p.h. maximum speed on level track and an 80 per cent heavier train at 35 m.p.h. maximum speed on level track and so on as shown in Groups II to VI.

Ordinarily Group I corresponds to a train weighing five times the weight of locomotive including tender, hence Groups II, III, etc., correspond to train weights of 7.5, 9, 11, 14 and 18 times the weight of locomotive. Certain types of locomotives may be capable of hauling trains weighing six times their weight at 50 m.p.h. For preliminary studies it can be assumed that the values of average running speeds given in Group I will hold substantially true for this combination. Likewise, the values in other groups may be applied to trains weighing 9, 10.8, 13.2, 16.8 and 21.6 times the weight of locomotives, but in order to obtain sufficient tractive effort for starting without slipping the drivers it will be necessary to have an abnormal weight on drivers or a booster must be provided.

In addition to the average running speeds for various weights of trains and lengths of run, the table also contains estimated values of fuel consumption per hour. The normal rate of firing is represented by unity. On down grades where speed limits are imposed and where the output of the locomotive is consequently limited the fuel consumption rate will also be reduced. When the grade is steep enough to overcome the friction of the train then the output of the locomotive is zero, but a certain amount of fuel is required to offset radiation losses and maintain steam pressure for auxiliary purposes. It is assumed that while trains are in motion, but the locomotives are delivering no output, the fuel consumption will be ⅛ (.125) of normal fuel consumption per hour. At other times it as assumed that the fuel consumption is proportional to the locomotive output.

3. Show How Track and Locomotive Capacities Combine

This is done by selecting a typical test period and constructing train-hour diagrams from data obtained from the train dispatcher sheets for that period. Fig. 3 and 4 show the actual train-hour diagrams north and southbound for an eight-day period—October 17-24, 1926, inclusive. It is usual in constructing train-hour diagrams to select a period of a week or ten days so as not to have too short a period to obtain representative conditions, and also for the purpose of obtaining data on 100 or more trains in each direction in order to determine the theoretical train-hour diagrams accurately. In this case the test period was not long enough to obtain data on 100 trains in each direction consequently the theoretical train-hour diagrams represented by the smooth curves do not agree as closely with the actual data as may be desired. Enough trains have been taken to illustrate the procedure and obtain a fair degree of accuracy.

The elapsed time is the time the crews are actually on duty which is obtained directly from the train dispatcher sheets or if convenient from the time cards of the crews. In order to avoid complicating the diagrams it is assumed that the train and engine crews work the same hours.

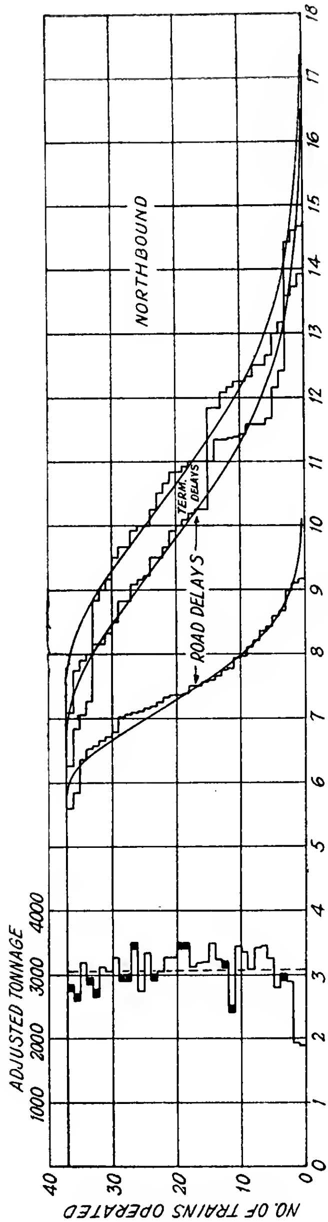

NORTHBOUND
TERM. DELAYS
ROAD DELAYS
HOURS
ADJUSTED TONNAGE
1000 2000 3000 4000
NO. OF TRAINS OPERATED
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Fig. 3

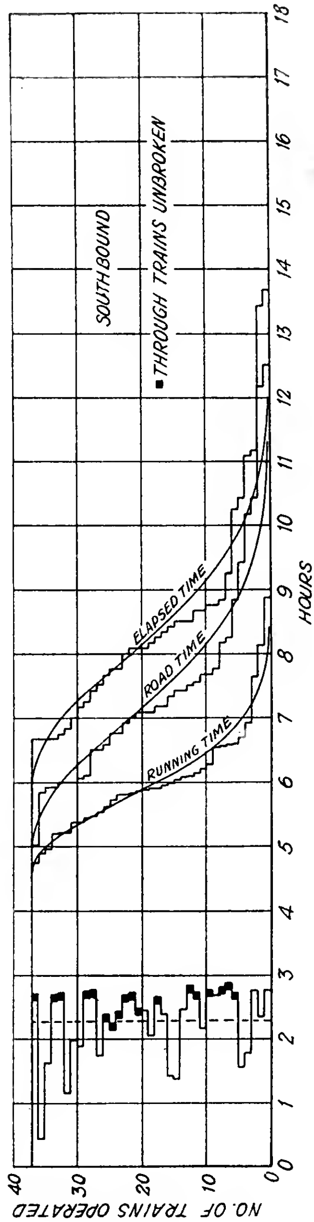

SOUTHBOUND
■ THROUGH TRAINS UNBROKEN
ELAPSED TIME
ROAD TIME
RUNNING TIME
HOURS
NO. OF TRAINS OPERATED
0 10 20 30 40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Fig. 4

The road time is the interval between the time the train leaves the initial terminal until it arrives at the final terminal. This is also obtained directly from the train dispatcher's sheets. The space between the road time and the elapsed time represents terminal delays.

The running time is intended to represent the time trains are in motion, and the space between the running time and the road time represents road delays. The only means available for obtaining the running time is to subtract the road delays from the road time. A record of delays and their causes usually appears on the train sheet in some form or other, or on the conductor's wheel report.

The car accountant's office works up from the conductor's wheel report the gross ton-miles made by each train from which the monthly statements are compiled. From this data the average train weights may be obtained for plotting against the corresponding running time. (The road times and the elapsed times do not correspond with the train weights.) The data from the conductor's wheel report for the period selected was not readily available, in lieu of which the adjusted tonnage data given on the train dispatcher's sheet was used.

Notation has been made on the charts to distinguish the trains which went through from those which set out or picked up cars. Northbound there were thirteen trains which went through solid against twenty-four which stopped to set out or pick up. Southbound there were eighteen trains which went through solid against nineteen which stopped to setout or pick up. This comment is made for the purpose of calling attention to one particular difference between north and southbound traffic. This fact in itself may be of little importance, but the reason for this difference may shed light on the character of the traffic in both directions, and explain other factors connected with the operation which may be worth while looking into. It also appears from the fact that the delays to northbound trains are much greater than they are to southbound trains that the conditions met with are important enough to favor the operation of southbound trains. There is opportunity for those who are familiar with the conditions to go further into the subject if desired.

The theoretical train-hour diagrams are calculated as described on page 739, Vol. 23, Proceedings of the A.R.E.A. for 1922 from which the minimum running, road and elapsed times are obtained. Usually more consistent results are obtained by using the theoretical minimum times rather than the actual minimum times because it frequently happens that the trains making the shortest times are also much lighter than the average. It is assumed that the theoretical train-hour diagrams automatically corrects for varying weights of trains and therefore applies to a condition where all trains are of uniform weight and equal to the average weight.

4. Simplify the Train-Hour Diagrams by Constructing the Corresponding Performance Charts

It is convenient to summarize the data derived from the train-hour diagrams as follows:

TABLE V—SUMMARY OF FREIGHT TRAIN PERFORMANCE FOR TEST PERIOD

October 17-24, 1926, Inclusive

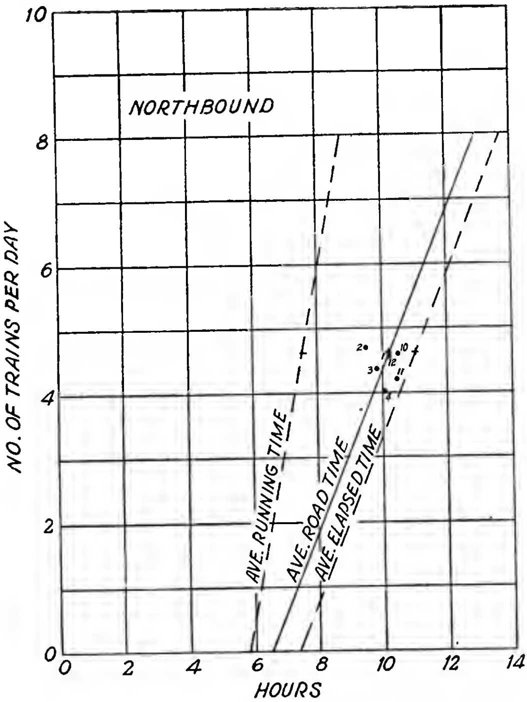
	North-bound	*South-bound*
Number of train operated	37	37
Average number of trains per day	4.63	4.63
Adjusted gross ton miles (1000)	13,886	10,385
Adjusted gross ton miles per day (1000)	1,736	1,298
Equivalent adjusted tons per day	14,183	10,605
Equivalent actual tons per day	11,630	8,484
Shortest running time, hours	5.80	4.60
Shortest road time, hours	6.50	5.00
Shortest elapsed time, hours	7.35	6.00
Average running time, hours	7.50	6.00
Average road time, hours	10.15	7.45
Average elapsed time, hours	11.00	8.45

Fig. 5 and 6 are constructed from data given in the above table as described below:

In the upper charts the shortest running, road and elapsed times are laid off along the horizontal axis, then on an ordinate corresponding to 4.63 trains per day the average running road and elapsed times are laid off The sloping lines connecting the corresponding points will determine the average running time, road time or elapsed time for any other number of trains per day. Thus, if six trains of the same kind and weight were operated per day the average running, road and elapsed times would be 8.00, 11.24 and 12.09 hours, respectively, for northbound trains as found by following the horizontal line corresponding to six trains per day to the points where it intersects the sloping lines. Similar data for soundbound trains can be found in like manner.

In the lower charts the shortest running road and the elapsed times are laid off along the horizontal axis the same as for the upper charts, then on ordinates corresponding to the equivalent actual tons, 11,630 northbound and 8484 southbound, the average running road and elapsed times are laid off. The sloping lines connecting the corresponding points will determine the average running time, road time or elapsed time for any other tons per day. The tons handled per day corresponding to any number of trains per day can be found by projecting from the upper charts to the lower chart. Thus, from the upper chart the average running time northbound for six trains per day is 8.00 hours and the tons corresponding to 8.00 hours average running time in the lower chart is 15,090.

In order to ascertain whether or not a representative period has been selected it is advisable to plot a few points showing where the actual performance for a number of months falls with reference to the sloping line for average road time. The numbered dots shown on the charts correspond to the months of the year and are obtained from the data given in table below, which may be obtained from the office of the car accountant.


NORTHBOUND
NO. OF TRAINS PER DAY
HOURS
AVE. RUNNING TIME
AVE. ROAD TIME
AVE. ELAPSED TIME

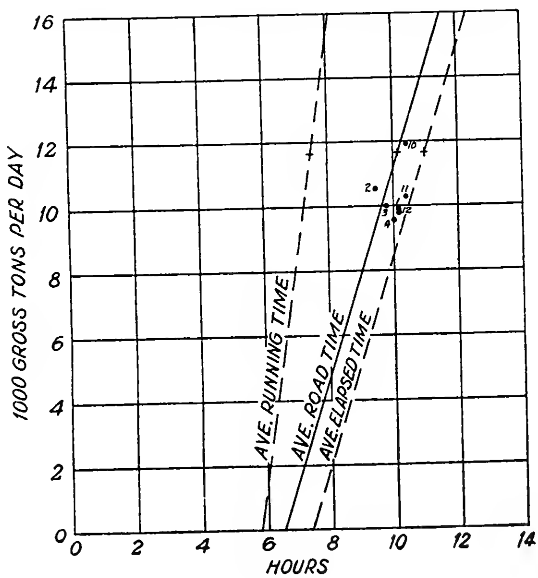

1000 GROSS TONS PER DAY
HOURS
AVE. RUNNING TIME
AVE. ROAD TIME
AVE. ELAPSED TIME

Fig. 5

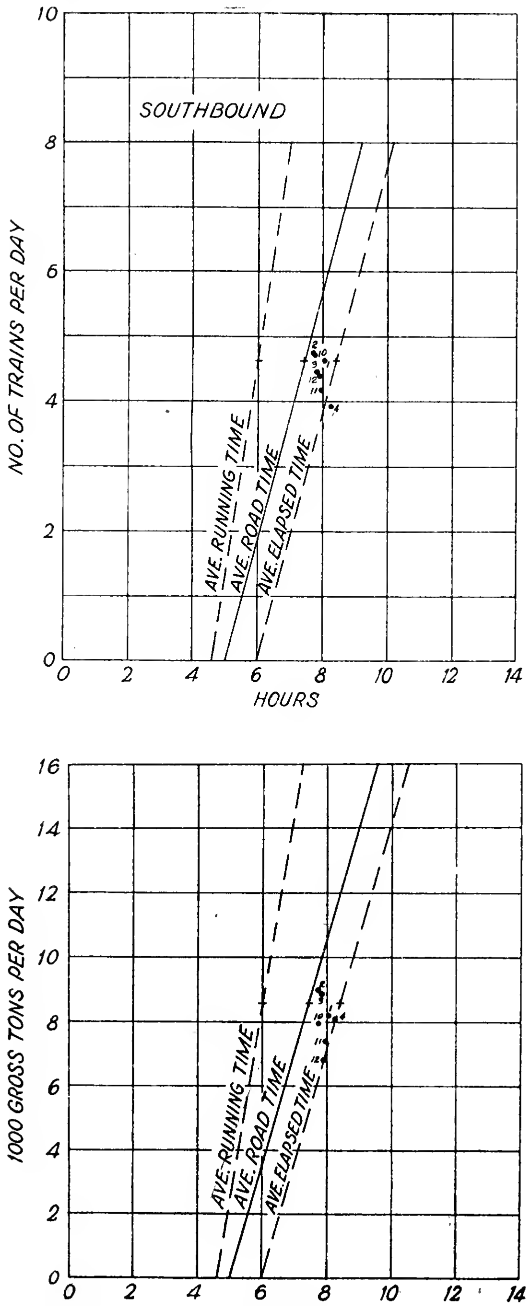

SOUTHBOUND
NO. OF TRAINS PER DAY
HOURS
AVE. RUNNING TIME
AVE. ROAD TIME
AVE. ELAPSED TIME
1000 GROSS TONS PER DAY
HOURS
AVE. RUNNING TIME
AVE. ROAD TIME
AVE. ELAPSED TIME

Fig. 6

TABLE VI—TYPICAL FREIGHT TRAIN PERFORMANCE STATISTICS
Seven Months Ending April 30, 1928

Date	*Train Miles*	*Gross Ton Miles*	*Train Hrs.*	*Trains Per Day*	*Gr. Tons Per Day*	*Ave. Hrs. Per Tr.*	*Ave. Tr. Wt.*
			NORTHBOUND				
1927							
Oct.	17,425	45,179,103	1,493	4.591	11,910	10.48	2,593
Nov.	15,448	37,790,336	1,317	4.205	10,290	10.44	2,447
Dec.	17,308	37,094,426	1,445	4,565	9,790	10.21	2,142
1928							
Jan.	17,300	37,477,097	1,441	4.560	9,880	10.20	2,165
Feb.	16,675	37,364,485	1,295	4.700	10,525	9.50	2,240
Mar.	16,564	37,907,789	1,329	4.370	10,000	9.81	2,286
Apr.	14,764	35,073,695	1,213	4.025	9,560	10.05	2,375
			SOUTHBOUND				
Oct.	17,837	30,040,234	1,132	4.705	7,930	7.76	1,685
Nov.	15,323	27,081,923	998	4.180	7,380	7.97	1,766
Dec.	16,668	25,768,904	1,079	4.395	6,790	7.91	1,540
1928							
Jan.	17,558	30,939,535	1,157	4.635	8,160	8.06	1,760
Feb.	16,807	31,786,679	1,061	4.735	8,940	7.73	1,890
Mar.	16,919	33,515,184	1,082	4.460	8,840	7.82	1,980
Apr.	14,409	29,681,165	974	3.925	8,080	8.27	2,060

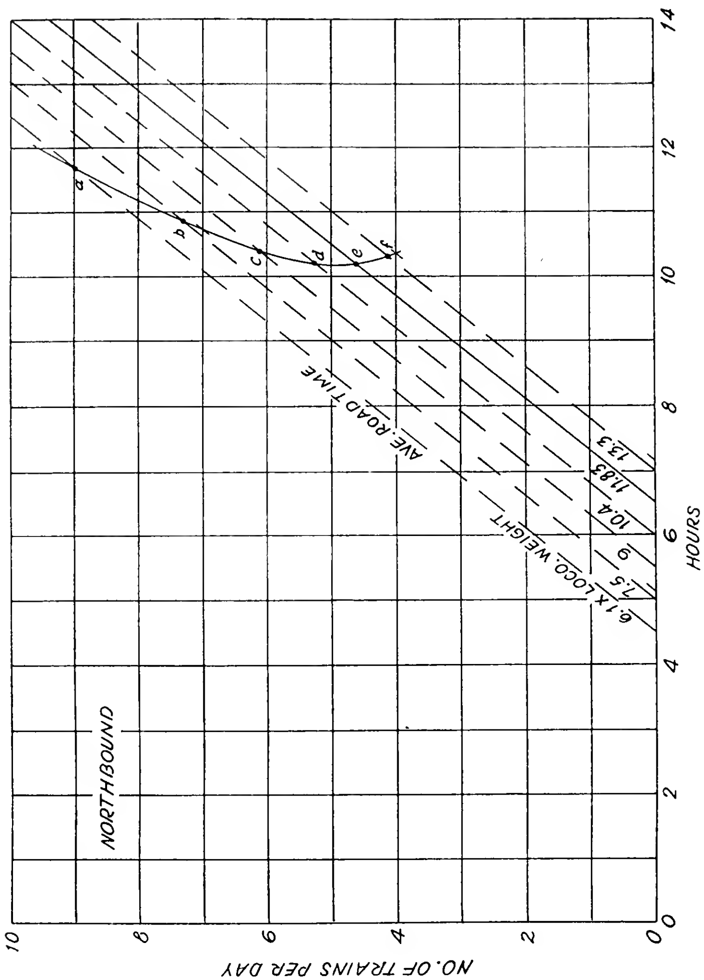
On account of the fact that most of the numbered dots fall below the line obtained as described above indicates that the performance during the test period was better than the average.

5. Determine the Weight of Train Which Will Give the Best Performance, Assuming a Definite Tonnage to Be Handled Per Day and No Changes to be Made in Size of Motive Power or in Amount of Passing Tracks

The procedure is briefly as follows:

Transfer the lines in the upper charts of Fig. 5 and 6 for average road time to new diagrams as shown by the solid lines in Fig. 7 and 8. When constructing the new diagram it is preferable to enlarge the horizontal scale so as to obtain greater accuracy in construction. At intervals of half an hour or less draw a series of lines, as indicated by the dotted lines, parallel to the solid lines which have been transferred from Fig. 5 and 6. The dotted lines at the left of the solid line are assumed to represent the average road time of trains which are lighter than those operated during the test period (represented by the solid line). Being lighter they can be hauled over the road faster and the time for the same density of traffic will be shorter than that represented by the solid line. The dotted lines at the right of the solid line are assumed to represent the average road time of trains which are heavier than those operated during the test period, consequently the road time will be longer than that shown by the solid line for the same number of trains.

In the space below the lower chart, construct charts laid off to the same horizontal scale as the upper charts. For the vertical ordinates use a scale to show the ratio of train weight to locomotive weight. Plot on this diagram the locomotive performance as obtained from Table IV. The following data concerning locomotives in service must be available before the locomotive performance can be obtained.


NORTHBOUND
AVE. ROAD TIME
6.1 x LOCO. WEIGHT
7.5
9
10.4
11.83
13.3
HOURS
NO. OF TRAINS PER DAY
a
b
c
d
e
f

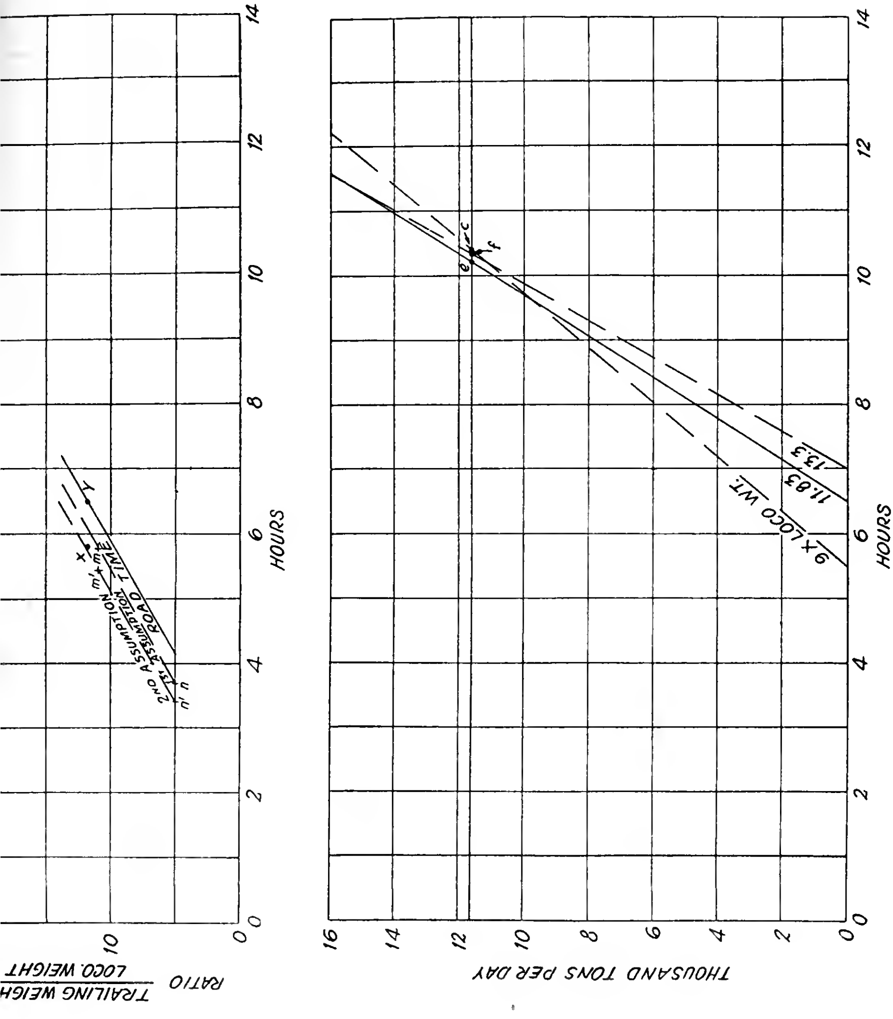
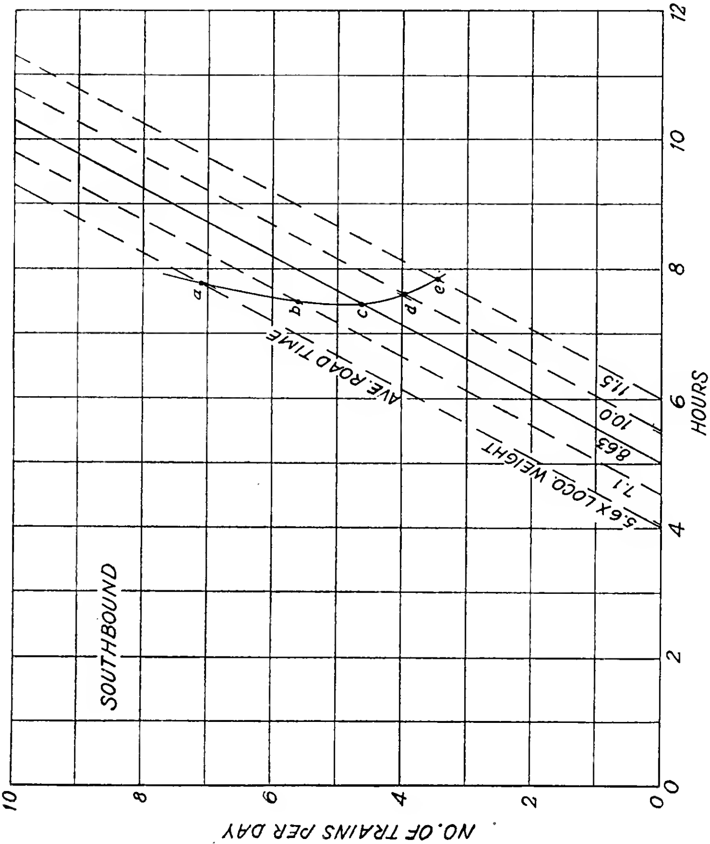
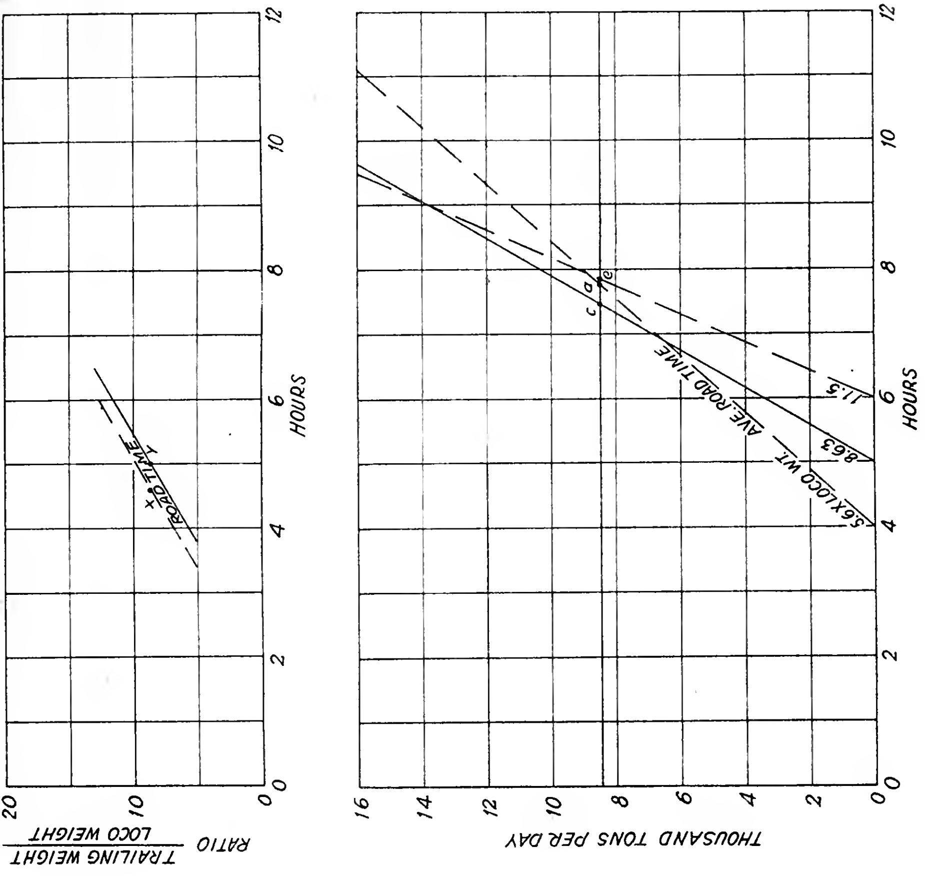

HOURS
THOUSAND TONS PER DAY
RATIO TRAILING WEIGHT / LOCO. WEIGHT
13.3
11.83
9 x LOCO WT.
2ND ASSUMPTION
1ST ASSUMPTION
TIME
ROAD

FIG. 7


SOUTHBOUND
HOURS
NO. OF TRAINS PER DAY
AVE. ROAD TIME
5.6 x LOCO. WEIGHT
7.1
8.63
10.0
11.5
a
b
c
d
e
0
2
4
6
8
10
12



HOURS
HOURS
ROAD TIME
RATIO TRAILING WEIGHT / LOCO WEIGHT
THOUSAND TONS PER DAY
AVE. ROAD TIME
5.6 x LOCO WT.
8.63
11.5

FIG. 8

TABLE VII—DESCRIPTION OF FREIGHT LOCOMOTIVES IN SERVICE

Wheel arrangement	2-8-0
Weight on drivers, lb.	224,000
Total weight engine and tender working order	425,000
Boiler pressure, lb. per sq. inch	185
Heating surface firebox, sq. ft.	195
Tubes and flues	2,828
Superheater	702
Grate area, sq. ft.	63.1
Number of cylinders	2
Diameter cylinders, inches	26
Stroke, inches	30
Diameter of drivers, inches	57
Stoker	None
Feed water heater	None
Booster	None

The total weight of locomotive and tender as given above is 212.5 tons and the average weight of freight train northbound is 2515 or 11.83 times the weight of the locomotive. As shown in Table V the minimum running time found for northbound trains was 5.8 hours. In the chart at the bottom of Fig. 6 follow the horizontal line corresponding to 11.83 to the vertical line corresponding to 5.8 hours and plot the point X. The average running speeds which will come nearest meeting this condition will be found in Table IV, Group IV, for a train weight eleven times the weight of locomotive. On account of the fact that the profile is composed of relatively short up and down grades of nearly 0.5 per cent the average running speed may be approximated by taking an average between the speeds shown for a +0.4 per cent grade and a —0.4 per cent grade.* In so doing it is necessary to make a note of speed limits, if any exist. In this case a maximum speed of 35 m.p.h. is imposed on the type of freight locomotives in service, hence in selecting average running speeds on —0.4 per cent grade care should be used to see that speeds higher than those corresponding to a maximum of 35 m.p.h. are not used. Next assume that stops will average one in every ten miles, then from Group IV under 10 miles between stops will be found 30.4 m.p.h. corresponding to —0.4 per cent grade and 35 m.p.h. maximum speed and 11.9 m.p.h. corresponding to +0.4 per cent grade, the average is 21.15 m.p.h. The running time for 122.4 miles corresponding to 21.15 m.p.h. is $122.4 \div 21.15 = 5.79$ hours. Plot this time against a train weight of eleven times the weight of locomotive in the lower chart for northbound trains as indicated by point m.

Assume that it is proposed to haul trains weighing five times the weight of the locomotive and the speed limits on down grade is raised to 50 m.p.h. Then from Group I under 10 miles between stops will be found 41 m.p.h. corresponding to —0.4 per cent grade and 25.3 m.p.h. corresponding to +0.4 per cent grade, the average is 33.15 m.p.h. The corresponding running time for 122.4 miles is 3.69 hours. Plot this time against a train weight of five

*See form for Case II under Fuel Estimates for outline of method to be used for Apex Profiles.

times the weight of locomotive; point n. Connect this point with point m corresponding to eleven times the weight of locomotive by dotted line, and extend it to meet the horizontal line for fourteen times the locomotive weight.

The point X lies off this line, indicating that the first assumptions are not close enough to represent actual operating conditions. To obtain a closer approximation to actual operating conditions try average running speeds corresponding to stops 20 miles apart and proceed as above and find the points m′ and n′. The results obtained are indicated by the second dotted line marked second assumptions. Point X now lies between the two dotted lines, indicating that stops probably average between 10 and 20 miles apart actually.

On account of the fact that it is proposed to deal with average road times and not with average running times, the point Y is plotted on the same horizontal line as X but corresponding to the minimum road time, 6.50 hours (northbound). Then a solid line marked "road time" is drawn through Y parallel to the dotted line previously constructed. Project the points where the dotted lines in the upper chart cross the horizontal axis down to the solid line marked "road time" and across to the vertical axis to find the weight of trains. Mark the dotted lines in the upper chart to correspond with the weight found.

On the basis of the tonnage handled during the test period it took an average of 4.63 trains per day to handle 11,630 tons; each train, therefore, weighed 2,515 tons or 11.83 times the weight of the locomotive. If this same tonnage were handled in trains weighing 1,296 tons, or 6.10 times the weight of locomotive, it would require 8.97 trains per day. Point *a* on the dotted line in the upper diagram corresponding to a train weight of 6.10 times the weight of locomotive indicates 8.97 trains per day. Likewise points *b, c, d, e* and *f* are plotted to indicate the number of trains required to handle 11,630 tons per day if the train weighs 7.5, 9.0, 10.4, 11.83 and 13.3 times the locomotive weight. When these points are connected by the line *af* it shows that the best average road time per train is obtained when the train weight is between 10.4 and 11.83 times the locomotive weight.

The points *c, e* and *f* have been projected down to the horizontal line in the lower chart corresponding to 11,630 tons per day. Likewise, the minimum road times corresponding to 9.0, 11.83 and 13.3 have been projected to the horizontal axis of the lower chart. The sloping lines corresponding to train weights of 9.0, 11.83 and 13.3 times the locomotive weight are drawn through the projection of *c, e* and *f*, respectively, and the corresponding points on the horizontal axis.

The charts for southbound trains are obtained in a similar manner, but they indicate a best average road time for a train weighing 8.63 times the weight of locomotive instead of 11.83 for northbound trains. The northbound tonnage determines the number of trains northbound, which must be balanced by an equal number of southbound trains. If the southbound tonnage were more nearly equal to the northbound tonnage both the northbound and southbound performances might be affected, but the greatest tendency would be to force a longer running time on southbound trains because of their increased weight and at the same time more nearly equalize the road delays between north and southbound trains. This would change the shape of the southbound train hour diagrams of Fig. 4 and likewise the position and slope of lines in the upper charts of Fig. 6 and 8 would change. The net effect would be that a different weight of train would be found to give the best performance southbound but it would correspond to the same number of trains which would give the best performance northbound. In other words, conditions pertaining to train movements in the limiting direction govern the weights of trains which will give the best performance.

In regard to speed limits Table IV shows that on level track the maximum speeds at which a locomotive will haul a train is determined by the weight of the train. That is, if it is necessary to limit the speed of a train to 50 m.p.h. maximum speed it only means loading the locomotive with a train weighing enough to keep the speed below 50 miles per hour. If the weight train it is desired to operate is such that the locomotive will be able to haul it at 50 m.p.h., then it is uneconomical to place a limit of 40 to 45 m.p.h. on the speed; it is better to increase the weight of train to a point where the speed will not be over 40-45 m.p.h. Therefore, on level track the speeds are naturally limited by the weight of the train.

On down grades, particularly steep grades, the speeds it is possible for trains to run, are naturally unlimited, consequently it is necessary to place arbitrary restrictions on the speeds in order to keep trains under safe control. Between level track and heavy grades there come the light or easy grades where it is necessary to use power down grade but where excessive speeds may be obtained if full power of the locomotive is utilized. In these cases it is necessary to place speed limits on the operations. Assume that grades up to 0.4 per cent are considered light grades and it is desired to haul trains weighing 11 times the weight of locomotive, what ought to be the speed limit set for train operation? Ordinarily it is expected to get as good operation over a line made up of up and down grades of 0.4 per cent as over a level track line. That is, on a 0.4 per cent up grade the maximum speed, as shown in Table IV, with a train weighing 11 times the weight of locomotive, is 12.9 miles per hour, on level track it is 30 m.p.h. and on down grades, assuming all grades are of equal length, the maximum speed should be $2 \times 30 - 12.9$ or 47.1 miles per hour if the operation equals that on level track with the same weight train. In other words, the standard of track should be suitable for a maximum speed of 47.1 m.p.h. and the type of locomotive employed should be adapted to run at that speed.

For grades over 0.4 per cent the rule not only does not hold but it is necessary to place speed limits on trains below that found for 0.4 per cent grades.

From this discussion it may be of advantage in this case to investigate the possibilities of increasing the speed limits from 35 m.p.h. to 40 or 50 m.p.h. as a means for obtaining better performance at small cost.

6. Compare Performance with Available Track Capacity

It is quite possible that the train which gives the best performance may not require the least investment or produce the least operating expense. For example, assume that it is proposed to make estimates to determine which of three operating methods will require the least investment and will cost the least to operate based upon handling 11,630 tons northbound and 8,484 tons southbound per day.

Plan I. Assume seven freight trains in each direction per day.
Plan II. Assume 4.63 freight trains in each direction per day.
Plan III. Assume four freight trains in each direction per day.

Tabulate the following data obtained from Fig. 7 and 8 for comparison:

	Plan I	*Plan II*	*Plan III*
Number of trains each way per day	7	4.625	4
Average weight of train northbound	1,647	2,515	2,908
Average weight of train southbound	1,212	1,834	2,121
Average road time per train northbound	10.73	10.15	10.35
Average road time per train southbound	7.75	7.45	7.58
Total train hours road time northbound	75.11	46.94	41.40
Total train hours road time southbound	54.25	34.46	30.32
Total	129.36	81.40	71.72
Track capacity, train hours	456	456	456
Per cent utilization of theoretical capacity	28.3	17.8	15.7

The item "Per cent utilization of theoretical capacity" indicates that for seven trains per day in each direction it is necessary to use more of the available track capacity than for four trains, which means that if a time comes when it is necessary to handle more traffic, more passing tracks will be required sooner under Plan I than under Plans II or III. Adding sidings is not usually an economical solution of the problem once the road is built, because generally it means destroying the uniformity of spacing, in which case the full benefit of additional sidings is not realized.

If it is assumed that the road is a new road and sidings can be spaced most advantageously for each condition of operation, then the three plans should be compared on the basis of the same performance, that is, on the basis of 10.15 hours average road time northbound and 7.45 hours average road time southbound. The total train hours per day road time would be 123.2, 81.4 and 70.4 respectively for Plans I, II and III. Assuming that the per cent utilization of theoretical capacity remained the same at 17.8, then the track capacity required would be 692, 456 and 396 train hours per day, which corresponds to 28, 19 and 17 sidings.

If the lengths of sidings are proportioned to the lengths of trains, say 1,500, 2,300 and 2,650 feet per siding, the total length of track will be about the same for all three plans. In order to compare the cost of installing the requisite number of sidings it will be necessary to prepare the proper detail estimates.

In general the problem usually arises in connection with roads where sidings are already installed, and new sidings are to be added. The problem is usually solved in a practical way by adding stretches of double track at one or both ends of the line instead of upsetting the spacing of sidings by setting in new sidings at odd places.

It may be well to add that the necessity for installing additional passing tracks is frequently due to train congestion during certain periods of the day. If this congestion can be reduced by lengthening the period, that is, by dispatching some trains earlier and other trains later, the need for additional passing tracks may be made less acute.

7. Compare Performance with Number of Locomotives Required

The number of locomotives required to do a given service bears some relation to the time crews are assigned to them; that is, a locomotive day may be divided into three parts, one part consisting of the time the locomotive is in the hands of the engine crew, another part consisting of the time when it is in the hands of the mechanical department, and a third part when it is idle or waiting to be called. When the traffic is heaviest every effort is made to keep crews on the locomotives as much of the time as possible. The mechanical department is pressed to keep locomotives on hand ready for call and there is little time when the locomotives are idle when they might be used.

The mechanical department usually takes the occasion during periods of light traffic to put the equipment in shape so that during periods of heavy traffic as little time as possible will be required to turn motive power. That is, motive power can be spared during light traffic periods for the motive power department to recondition and stored in white lead until needed to handle heavy traffic.

It is usually found that engine crew hours in freight service represent about 30 per cent of the total freight locomotive hours per year based upon locomotives owned but neglecting locomotives awaiting sale. On a per day basis this is equivalent to assuming freight locomotives will be in the hands of the crew 7.2 hours per day. The number of locomotives required may be obtained by dividing the crew hours per day by 7.2.

From Table V the elapsed time or time crews are on duty average 0.85 hours longer than the road time northbound and one hour southbound, so that the total crew hours for Plans I, II and III are respectively 142.3, 90.0 and 79.1 per day. On the above basis of 7.2 hours per day per locomotive owned there will be required 20, 13 and 11 locomotives for Plans I, II and III respectively. Fractions count as whole locomotives.

Investments in engine house and shop facilities needed for the care of locomotives will also be affected in somewhat the same way and there will be a corresponding expense incurred for maintenance of the facilities furnished.

8. Compare Performance with Locomotive Maintenance

The maintenance of locomotives bears some relation to the miles run. Plan I requires 1,714 miles per day; Plan II, 1,132 miles per day, and Plan III, 979 miles per day. The maintenance expense may not be proportional to the miles run for the reason that the overhead expense and other miscellaneous accounts may not increase appreciably, but the direct labor and material, which are the controlling accounts, will be approximately proportional to the miles run.

9. Compare Performance with Fuel Consumption

The fuel consumption values shown in Table IV represent the rates of burning fuel while locomotives are doing work or in motion. While locomotives are standing or when delayed, fuel is burned at a much slower rate, usually one-eighth to one-twelfth the normal rate when working up to capacity. Thus while locomotives are in transportation service (in the hands of the crews) fuel will be fired at three or more rates, one corresponding to full capacity when on level track or ascending grades, another corresponding to reduced capacity when necessary to reduce speed on down grades, and a third rate when trains are stopped. The total fuel consumption for the entire run will be equivalent to the sum of the products of the various rates times the corresponding hours.

When the profile is made up of a series of short moderate grades it can be shown that the momentum of the train acts to reduce the fuel consumption, that is, the fuel consumption approximates that expected for level track. In order to simplify the calculations the following forms are suggested for tabulating the data:

Form for Tabulating Fuel Consumption Estimates

CASE I—ROLLING PROFILE

(Relatively Short Up and Down Grades)

Item	Assumptions	Plan I N.B.	Plan I S.B.	Plan II N.B.	Plan II S.B.	Plan III N.B.	Plan III S.B.
1	Miles run	122.4	122.4	122.4	122.4	122.4	122.4
1A	Ave. grade ascending, %	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4
1B	Ave. grade descending, %	—0.4	—0.4	—0.4	—0.4	—0.4	—0.4
2	(Space for other par-						
3	ticulars, if any)						
4	Max. speed limit, m.p.h.	50	50	35	35	35	35
5	Number of trains	7.0	7.0	4.63	4.63	4.0	4.0
6	Ratio trailing, weight ÷ locomotive weight	7.82	5.70	11.83	8.63	13.67	9.98
7	Miles bet. stops, assumed	20	20	20	20	20	20
8	Minimum running time (see Note A)	4.35	3.65	5.70	4.64	6.33	5.10
9	Average delayed time	7.23	5.10	6.30	3.81	4.87	3.48
10	*Average elapsed time	11.58	8.75	11.00	8.45	11.20	8.58
11	Fuel consumption rate (see Note B)	.732	.708	.636	.624	.644	.629
12	†Fuel rate during delays	.100	.100	.100	.100	.100	.100
13	Item 8 × Item 11	3.184	2.584	3.625	2.895	4.077	3.208
14	Item 9 × Item 12	.723	.510	.630	.381	.487	.348
15	Total, Item 13 + Item 14	3.907	3.094	4.255	3.276	4.564	3.556
16	Item 15 × Item 5	27.349	21.658	19.701	15.168	18.256	14.224
17	Total, N.B. and S.B.	49.007		34.869		32.480	
18	Ratio	1.405		1.000		.932	

NOTE A—The minimum running time is obtained by plotting a chart similar to the chart at the bottom of Fig. 7 and 8, thus:

	Group I 50 m.p.h. Max.	Group IV 35 m.p.h. Max.
Average running speed up grade	26.8 m.p.h.	12.4 m.p.h.
Average running speed down grade	45.0 m.p.h.	32.6 m.p.h.
Average of up and down grade	35.9 m.p.h.	22.5 m.p.h.

Item I divided by the average speed up and down grade will give the minimum running time 3.41 and 5.44 corresponding to trains in Group I and Group IV, that is, to trains weighing five and eleven times the weight of locomotive. These points correspond to m′ and n′, Fig. 7. Draw line corresponding to m′ n′ and read the minimum running time corresponding to weights of trains given in Item 6. Enter these values under Item 8.

The reason for taking the average of the up and down grade values is to allow approximately for the momentum effect of the train. If the grades are long the procedure is described under Case II, Apex Profile.

*Average elapsed time equals average crew time, found in this case to be 0.85 hours longer than road time northbound and 1.0 hours longer southbound. (See Table V.)

NOTE B—The fuel consumption rate is obtained by plotting a chart similar to Fig. 10.

	50 m.p.h. Max. Group I	50 m.p.h. Max. Group V	35 m.p.h. Max. Group I	35 m.p.h. Max. Group V
Up grade	1.000	1.000	1.000	1.000
Down grade	.400	.610	.217	.291
Average	.700	.805	.609	.646

The average values show the relative fuel consumption per hour corresponding to trains in Group I and Group V, that is, to trains weighing five and fourteen times the weight of locomotive. These points correspond to A and E and A′ and E′, Fig. 10. Draw the lines AE and A′E′ and read the relative fuel consumption corresponding to weights of train given in Item 6. Enter these values under Item 11.

†The fuel consumed while locomotive is standing may be taken at one-eighth to one-twelfth the normal rate when working up to capacity.

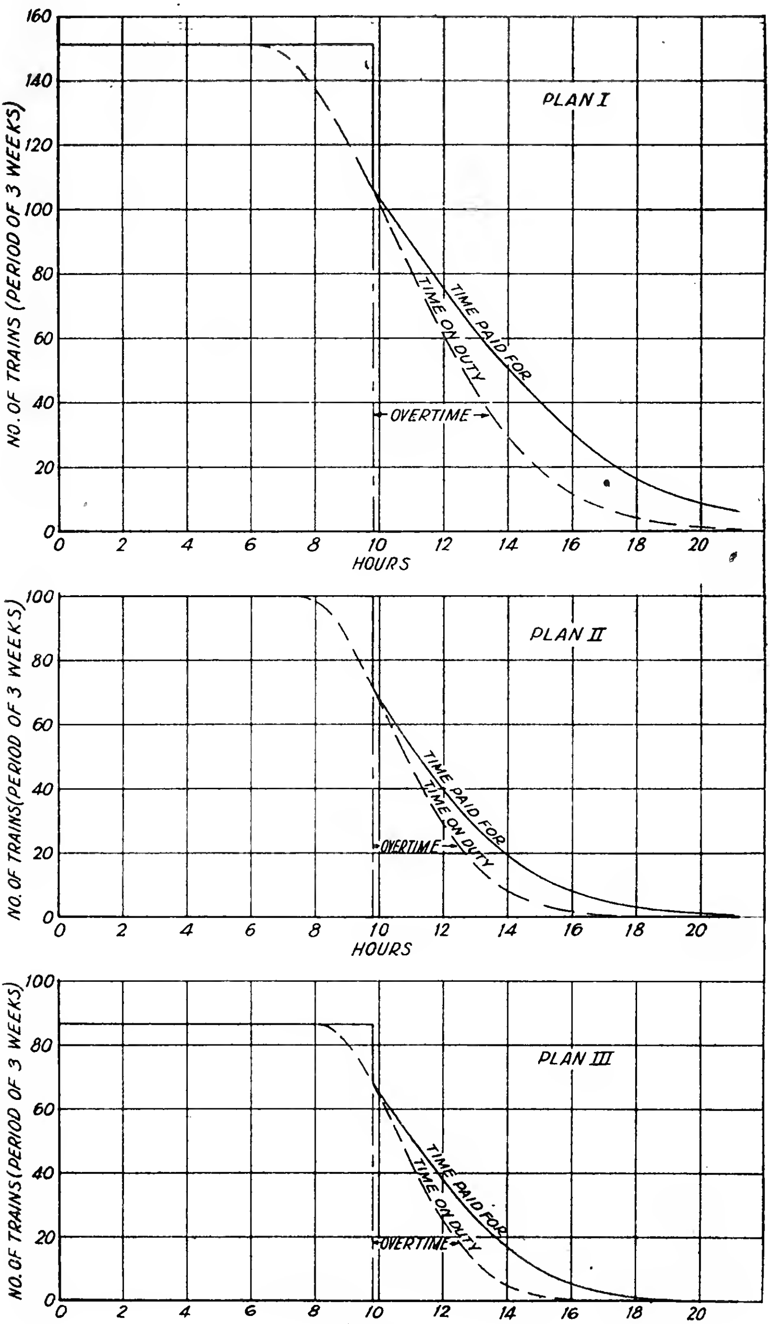

160
140
120
100
80
60
40
20
0
NO. OF TRAINS (PERIOD OF 3 WEEKS)
PLAN I
TIME PAID FOR
TIME ON DUTY
OVERTIME
0 2 4 6 8 10 12 14 16 18 20
HOURS
100
80
60
40
20
0
NO. OF TRAINS (PERIOD OF 3 WEEKS)
PLAN II
TIME PAID FOR
TIME ON DUTY
OVERTIME
0 2 4 6 8 10 12 14 16 18 20
HOURS
100
80
60
40
20
0
NO. OF TRAINS (PERIOD OF 3 WEEKS)
PLAN III
TIME PAID FOR
TIME ON DUTY
OVERTIME
0 2 4 6 8 10 12 14 16 18 20
HOURS

Fig. 9

Form for Tabulating Fuel Consumption Estimates

CASE II—APEX PROFILE

(Example to Illustrate Method)

Item	Assumption	Plan A E.B.	Plan A W.B.	Plan B E.B.	Plan B W.B.	Plan C E.B.	Plan C W.B.
1	Miles ascending grade...	61.2	61.2	61.2	61.2	61.2	61.2
1-A	Average grade	.4%	.4%	.4%	.4%	.4%	.4%
2	Miles descending grade.	61.2	61.2	61.2	61.2	61.2	61.2
2-A	Average grade	.4%	.4%	.4%	.4%	.4%	.4%
3	Miles level or other grades						
3-A							
4	Max. speed limit, m.p.h..	50	50	35	35	35	35
5	Number of trains.......	7.0	7.0	4.63	4.63	4.0	4.0
6	Ratio trailing, weight ÷ locomotive weight	7.82	5.70	11.83	8.63	13.67	9.98
7	Miles bet. stops, assumed.	20	20	20	20	20	20
8	Minimum running time						
	Up grade (1 and 1-A)..	3.50	2.58	5.30	3.93	6.15	4.50
	Down grade (2 and 2-A).	1.61	1.43	1.96	1.69	2.11	1.80
	Level (3 and 3-A)..... (See Note A)						
9	Average delayed time...	6.47	4.74	3.74	2.83	2.94	2.28
10	*Average elapsed time...	11.58	8.75	11.00	8.45	11.20	8.58
11	Fuel consumption rate						
	Up grade (1 and 1-A)..	1.000	1.000	1.000	1.000	1.000	1.000
	Down grade (2 and 2-A).	.465	.417	.273	.247	.289	.258
	Level (3 and 3-A)..... (See Note B)						
12	†Fuel rate during delays..	.100	.100	.100	.100	.100	.100
13	Item 8 × Item 11						
	Up grade (1 and 1-A)..	3.500	2.580	5.300	3.930	6.150	4.500
	Down grade (2 and 2-A).	.749	.596	.535	.417	.610	.464
	Level (3 and 3-A).....						
14	Item 9 × Item 12.....	.647	.474	.374	.283	.294	.228
15	Total, Item 13 + Item 14	4.896	3.650	6.209	4.630	7.054	5.192
16	Item 15 × Item 5......	34.272	25.550	28.748	21.437	28.216	20.768
17	Total, E.B. and W.B....	57.822		50.185		48.984	
18	Ratio	1.155		1.000		.977	

NOTE A.—Estimate the minimum running time by Sections thus:

	Group I 50 *m.p.h. Max.*	*Group IV* 35 *m.p.h. Max.*
Average running speed up grade (1-A)....	26.8 m.p.h.	12.4 m.p.h.
Average running speed down grade (2-A)..	45.0 m.p.h.	32.6 m.p.h.
Average running speed level grade (3-A)..		
Minimum running time up grade...........	2.28	4.94
Minimum running time down grade........	1.36	1.88
Minimum running time level...............		

(Item 1 ÷ 26.8 for Group I) (Item 1 ÷ 12.4 for Group IV)
(Item 2 ÷ 45 for Group I) (Item 2 ÷ 32.6 for Group IV)

Plot the hours 2.28 and 4.94 against the train weights corresponding to Group I and Group IV (5 and 11 times the weight of locomotive) and connect with a straight line. Read the minimum running time corresponding to weights of train given in Item 6. Enter these values under Item 8 up grade.

Plot the hours 1.36 and 1.88 and proceed as above to find the minimum running time for item 8 down grade.

*Average elapsed time for this case is unknown, assumed the same as for Case I.

NOTE B.—In order to interpolate for the values of fuel consumption down grade corresponding to the weights of trains given in Item 6, plot the values given in Table IV against the train weights for the respective groups.

†The fuel consumed while locomotive is standing may be taken at one-eighth to one-twelfth the normal rate when working up to capacity.

10. Compare Performance with Crew Expense

In the United States, engine and train crews are paid on the basis of miles or hours, depending upon conditions set forth in the wage agreement entered into from time to time by the management and the men. The essential provisions of these agreements it is proposed to deal with in this discussion are briefly as follows:

(a) When the distance run is 100 miles or less the pay is the same as for 100 miles and is equivalent to the pay for eight hours unless the time on duty exceeds eight hours.

(b) If the time on duty exceeds eight hours, the crews are paid for overtime at the rate of time and a half or $\frac{3}{16}$ times the daily rate for all time over eight hours.

(c) When the distance run is more than 100 miles the crews are paid pro rata on a mileage basis except for overtime.

(d) For runs of over 100 miles, overtime begins when the hours on duty equal the miles run divided by 12.5. For example, on a run of 125 miles the pay on a mileage basis would be 25 per cent more than for 100 miles but overtime would not start until the crews had been out $\frac{125}{12.5} = 10$ hours.

(e) When the time on duty exceeds the miles run divided by 12.5 the crews are paid overtime at the rate of time and a half or $\frac{3}{16}$ times the rate for 100 miles for all overtime.

(f) Federal regulations limit the hours on duty to 16 hours. When crews have been out 16 hours they must be relieved and given eight hours' rest before going on duty again. Additional expense is incurred whenever the time exceeds this limit. In these studies the additional expense can be neglected but it is important to make note of the number of trains which would naturally exceed the 16-hour limit.

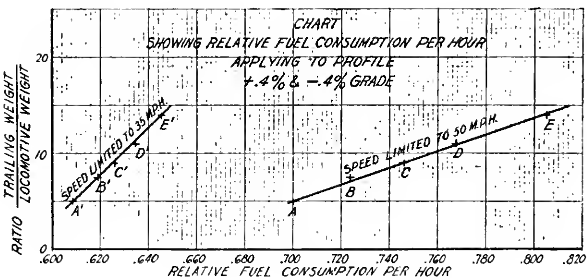


Fig. 10

Fig. 9 shows three theoretical crew expense diagrams prepared to illustrate a method for estimating crew expense. These diagrams apply to northbound trains for Plans I, II and III. The elapsed time shown in Fig. 3 shows the actual time crews were on duty during an eight-day period when 37 trains were operated. On account of the small number of trains considered the theoretical train-hour diagram which is calculated in the usual manner fails to agree closely with the actual results. In order to correct for these errors assume test period covered three weeks and the elapsed time obtained from 100 trains is represented by the dotted line shown for Plan II and marked "Time on duty."

This line shows that out of 100 trains the shortest time any crew was on duty was 7.35 hours. See also Table V. Likewise out of 100 trains the crews of 71 were on duty 9.8 hours or longer and only 8 crews were on duty more than 14 hours. Assume that the crews are allowed 122.4 miles for the run, that is, they would be paid for 122.4 miles at the mileage rate which is equivalent to $\frac{122.4}{12.5}$ or 9.8 hours at the hourly rate. All of the crews who were on duty 9.8 hours or less would receive the same pay (122.4 miles at mileage rates or 9.8 hours at the hourly rate). There are 29 out of 100 crews who would be in this class and would draw pay for the same number of hours as indicated by the solid vertical line corresponding to 9.8 hours.

All of the crews who were on duty more than 9.8 hours would be paid for overtime. There would be 71 out of 100 crews who would be in this class and all of them theoretically would be paid for a different number of hours' depending upon the amount of overtime each was on duty. The area under the dotted line and to the right of the vertical line corresponding to 9.8 hours represents the total hours overtime the 71 crews were on duty. For every hour represented by this area the participating crews would be paid for an hour and a half. Thus by making the overtime diagram 50 per cent longer (horizontally) as indicated by the solid line an area is obtained which represents the equivalent hours paid for. When these diagrams are completed a graphical comparison is obtained showing the relation between the hours the crews are on duty and the hours they are paid for. The area enclosed by the dotted line and the two axes represents the hours the crews are on duty and the area enclosed by the solid lines represents the hours paid for.

The diagrams for Plan I and Plan III have been plotted for comparison with Plan II. Under Plan I it would have required the operation of 151.3 trains during the same period assumed for Plan II instead of 100 trains and instead of a shortest time of 7.35 hours the shortest time would have been 6.06 hours. Likewise under Plan III there would have been 86.5 trains operated and the shortest time would have been 8.05 hours.

The areas of the three diagrams represent the relative crew expense for the three plans of operation.

As a matter of procedure it is interesting to call attention to the number of trains which would be near the 16-hour limit. Under Plan I there would be about eleven trains every three weeks or an average of one every other day, which would require special effort to prevent it exceeding the 16-hour limit. Under Plan II there would be only one train every three weeks which would approach this limit and under Plan III there would be one occurrence in about every six weeks. From this analysis it would appear that Plan I would be more troublesome from an operating standpoint than either Plan II or Plan III.

Form for Tabulating Crew Expense Estimates

Examples *Item*		*Plan I*		*Plan II*		*Plan III*	
		N.B.	*S.B.*	*N.B.*	*S.B.*	*N.B.*	*S.B.*
1	Number of trains (N)	151.3	151.3	100	100	86.5	86.5
2	Average crew time (T)	11.58	8.75	11.00	8.45	11.20	8.58
3	Shortest crew time (t_o)	6.06	5.04	7.35	6.00	8.05	6.44
4	$T - t_o$	5.52	3.71	3.65	2.45	3.15	2.14
5	$\frac{\sqrt{\pi}}{2(T - t_o)}$ (n)	.161	.239	.243	.362	.281	.418
6	Time overtime begins (T')	9.8	9.8	9.8	9.8	9.8	9.8
7	$T' - t_o = (t)$	3.74	4.76	2.45	3.80	1.75	3.36
8	Item 5 × Item 7 = (nt)	.600	1.138	.595	1.375	.492	1.405
9	Note A	.605	.890	.600	.948	.513	.952
10	1.0 — Item 9	.395	.110	.400	.052	.487	.048
11	Item 4 × Item 10 = Average overtime	2.16	.41	1.46	.13	1.53	.10
12	Item 1 × Item 2 = hours on duty	1752	1324	1100	845	969	742
	Total, north and south bound		3076		1945		1611
13	Hours paid for:						
	Item 1 × Item 6 = straight time	1483	1483	980	980	848	848
	Item 1 × Item 11 = actual overtime	327	62	146	13	132	9
	½ actual overtime = punitive overtime	164	31	73	7	66	4
	Total	1974	1576	1199	1000	1046	861
	Total north and south bound		3550		2199		1907
14	**Item 13 × hourly rates = crew expense**						

Note A.—From curve B, Fig. 11, find ratio corresponding to value of nt shown in Item 6. Values of nt are shown along the upper margin of Fig. 11.

The methods used for calculating the theoretical elapsed time or time crews are on duty was described in the report of this Committee for 1922. (See pages 738-743, Vol. 23, Proceedings of the A.R.E.A., for derivation of formulas.) On account of the fact that it takes time to become expert in the use of the formulas a form has been devised to indicate the mathematical operations and tabulate the results. Fig. 11 will be found useful in plotting the train-hour diagrams and estimating overtime.

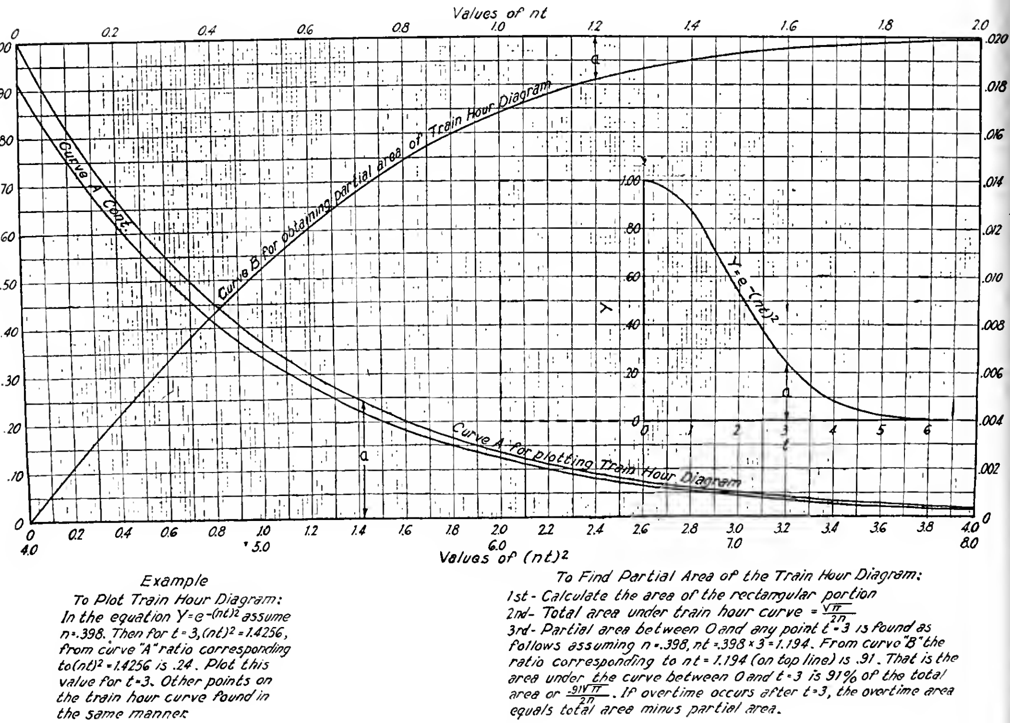


Fig. 11

11. Compare Performance with Other Items of Expense

Other items of expense too numerous to attempt to discuss will be more or less affected by changes in methods of operation. The nature of the effects will be obvious from the changes it is proposed to make. For instance, assume that it is proposed to improve the average road time by reducing delays, having in mind the opening up of more telegraph offices. In this case the item of dispatching trains would be expected to increase, but in return if better dispatching resulted and the time of crews was reduced as expected, then there would be a reduction in crew expense and fuel.

Having made an analysis such as described above it is possible to ascertain how much the service may be improved by the adoption of any given plan and what items of capital expenditures and operating expense will be affected. It is believed that in the final analysis, studies of this character will be most valuable in connection with the formulation of plans for taking care of future requirements.

Exhibit B

STUDY AND REPORT OF IMPROVEMENTS MADE ON A HEAVY TRAFFIC NORTH AND SOUTH RAILWAY

The North and South Railway operated 345 miles of road, divided into three operating divisions, of which the Northern Division (122 miles) is the most important as a traffic carrier.

Freight traffic increased 60 per cent on the Northern Division from 1921 to 1924. In 1924, 43 miles of this Division were double tracks and 79 miles were single track. As the traffic was quite dense, slow freight train movement and excessive overtime resulted. Relief was necessary in order to take care of increasing business.

To obtain this relief, 58 miles of second track were added, making a total of 101 miles of double track. The effect of this improvement is shown by a comparison of train operations in June, 1924, and June, 1926, supplemented by figures for June, 1927. June, 1924, was selected as the basis for all comparisons because it was considered to be a representative normal month prior to double tracking. June, 1926, was selected because it gives a comparison of operations immediately after the full benefits of the improvement were felt, and June, 1927, gives results of operations a year later over the improved Division.

Traffic density on the Northern Division measured by both the number of freight trains run, and the number of gross ton miles, showed a decided increase in June, 1926, over June, 1924, and June, 1927, shows a further increase over June, 1926, of about 10 per cent. The average road time of freight trains was lowered approximately 25 per cent over the three-year period. Gross ton miles per train hour increased approximately 50 per cent over the three years.

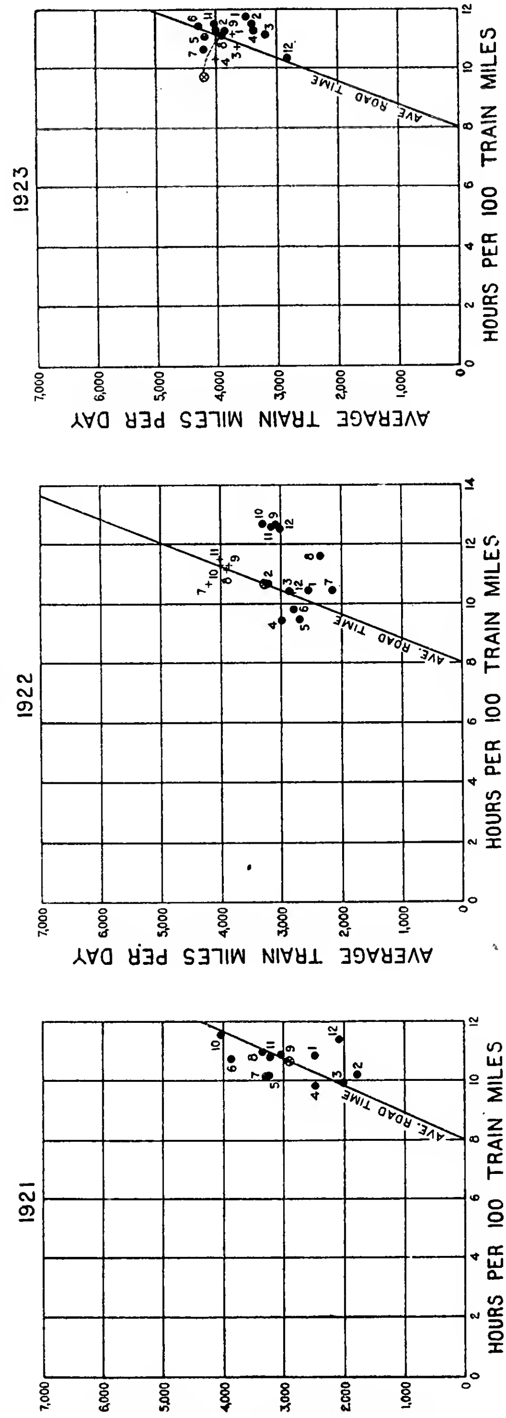
In addition to the increased efficiency that has resulted from the extension of the double track, the track capacity between engine terminals has been increased to practically double.

TRAFFIC

The traffic on the North and South Railway consists largely of coal, which moves northward over the Northern Division to rail connections or to the coal dock for trans-shipment by vessel. It is seen from Table I, page 744, that the seven years, 1921-1927, inclusive, were years of growth. The traffic density, as measured by both train-miles and gross ton-miles, shows a steady increase except for a minor set-back in 1922. Compared with 1921, the gross ton-miles increased 46 per cent in 1924, 70 per cent in 1925, 67 per cent in 1926 and 89 per cent in 1927. All movement of bituminous coal in the United States was affected by the British Labor Strike in 1926. The movement on the North and South Railway was abnormally affected by reason of this strike, and Table I shows a decrease of 3 per cent in the traffic of 1926 compared with the previous peak of 1925.

During 1926 bituminous coal alone made up 80.12 per cent of the total freight traffic handled by the North and South Railway. Of the 18,346,929

Train Performance Charts from System O S Charts



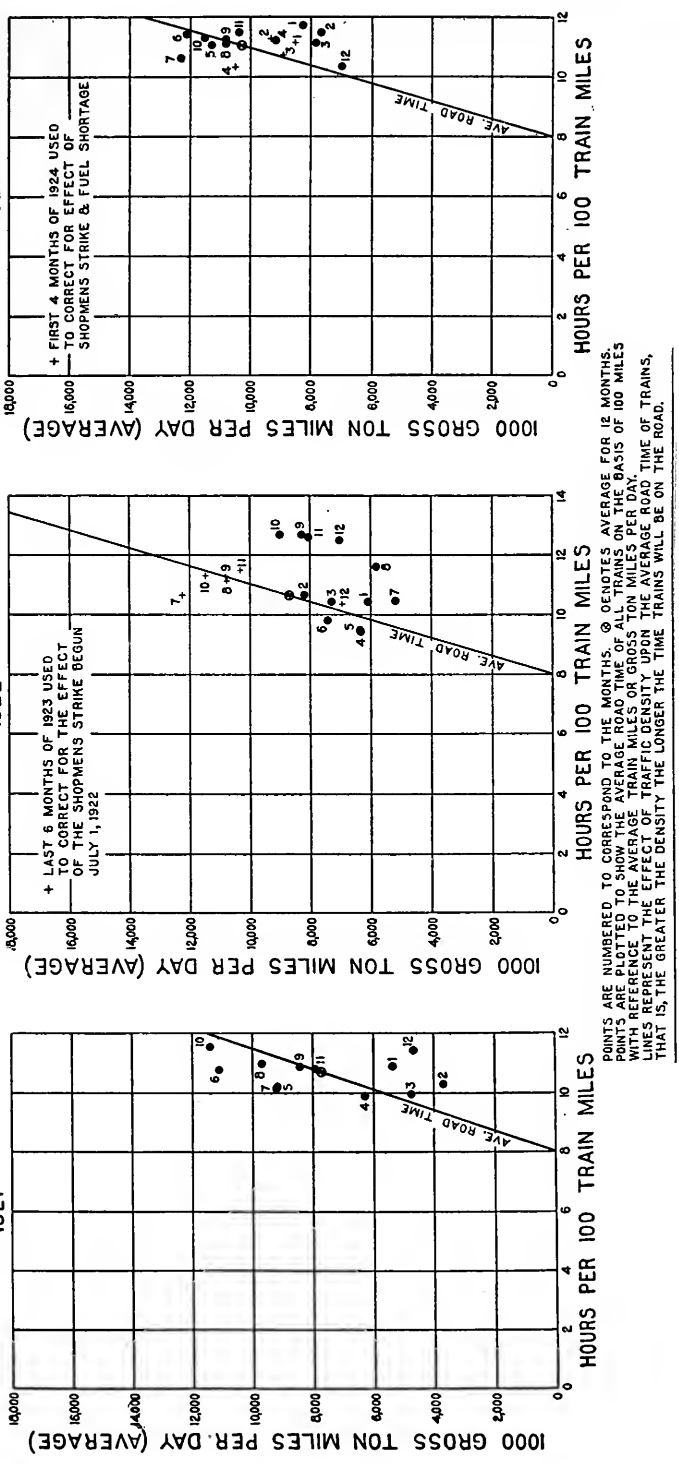
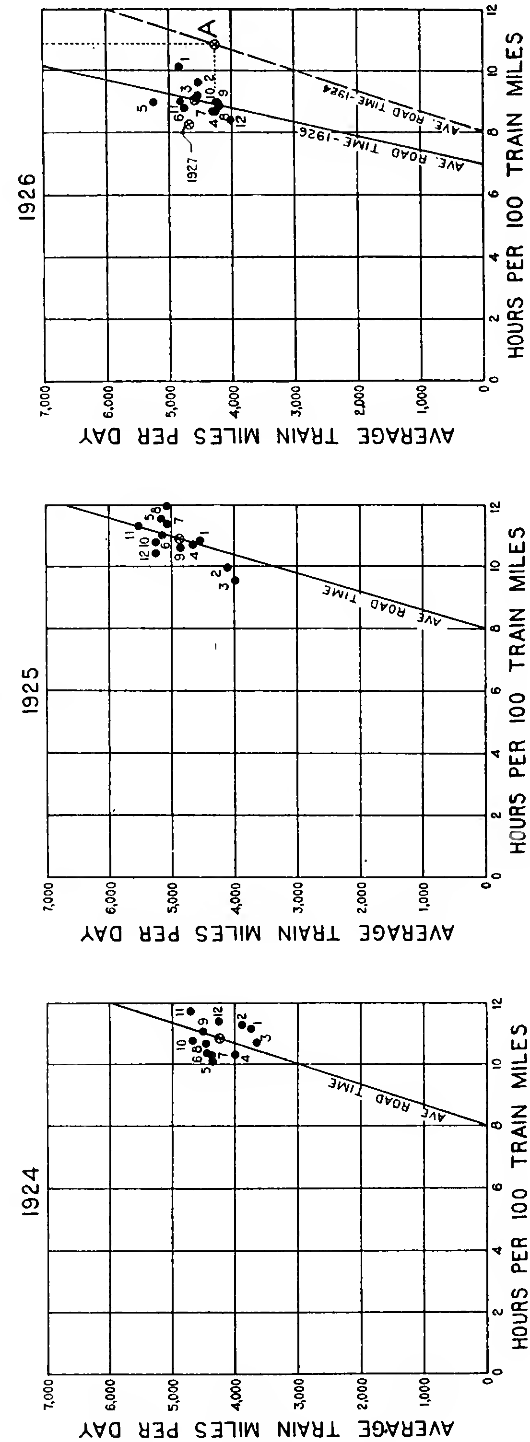
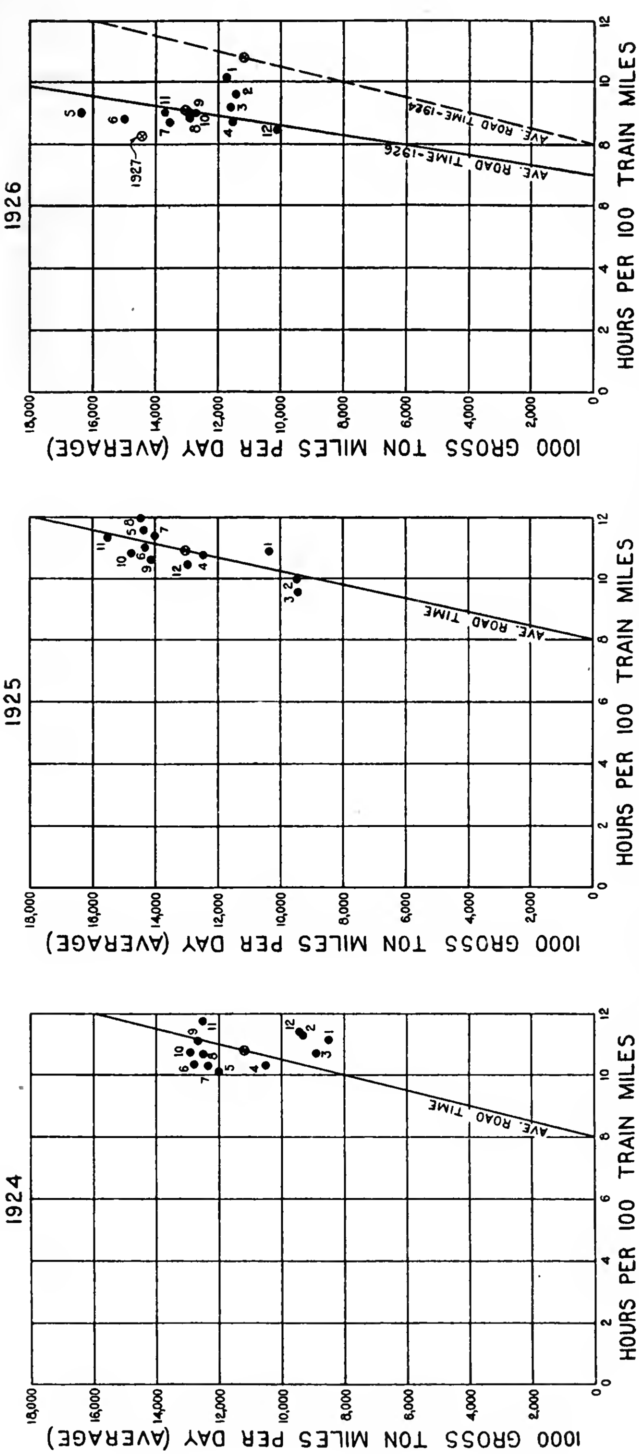

1921
1922
1923
1000 GROSS TON MILES PER DAY (AVERAGE)
HOURS PER 100 TRAIN MILES
AVE. ROAD TIME
+ LAST 6 MONTHS OF 1923 USED TO CORRECT FOR THE EFFECT OF THE SHOPMENS STRIKE BEGUN JULY 1, 1922
+ FIRST 4 MONTHS OF 1924 USED TO CORRECT FOR EFFECT OF SHOPMENS STRIKE & FUEL SHORTAGE
POINTS ARE NUMBERED TO CORRESPOND TO THE MONTHS. ⊗ DENOTES AVERAGE FOR 12 MONTHS.
POINTS ARE PLOTTED TO SHOW THE AVERAGE ROAD TIME OF ALL TRAINS ON THE BASIS OF 100 MILES
WITH REFERENCE TO THE AVERAGE TRAIN MILES OR GROSS TON MILES PER DAY.
LINES REPRESENT THE EFFECT OF TRAFFIC DENSITY UPON THE AVERAGE ROAD TIME OF TRAINS,
THAT IS, THE GREATER THE DENSITY THE LONGER THE TIME TRAINS WILL BE ON THE ROAD.

Fig. 1

Train Performance Charts from System O S Charts





POINTS ARE NUMBERED TO CORRESPOND TO THE MONTHS. ⊗ DENOTES AVERAGE FOR 12 MONTHS.
POINTS ARE PLOTTED TO SHOW THE AVERAGE ROAD TIME OF ALL TRAINS ON THE BASIS OF 100 MILES
WITH REFERENCE TO THE AVERAGE TRAIN MILES OR GROSS TON MILES PER DAY.
LINES REPRESENT THE EFFECT OF TRAFFIC DENSITY UPON THE AVERAGE ROAD TIME OF TRAINS,
THAT IS, THE GREATER THE DENSITY THE LONGER THE TIME TRAINS WILL BE ON THE ROAD.

Fig. 2

tons of coal handled, 17,071,156 tons, or 93.0 per cent, originated on connecting lines.

TABLE I

Year	Average Miles Operated	Freight Train Miles Per Year	Freight Train Miles Per Day	Freight Train Miles Index	1000 Gross Ton Miles Per Year	1000 Gross Ton Miles Per Day	1000 Gross Ton Miles Index
1921	345	1,065,833	2,920	100	2,803,595	7,681	100
1922	345	1,026,045	2,811	96	2,587,350	7,088	92
1923	345	1,362,235	3,732	127	3,623,497	9,927	129
1924	345	1,554,174	4,258	146	4,097,079	11,224	146
1925	345	1,781,797	4,881	167	4,758,037	13,035	170
1926	345	1,649,705	4,520	154	4,686,345	12,839	167
1927*	345	1,713,000	4,694	161	5,310,000	14,549	189

NOTE *.—Based on year, December 1, 1926-November 30, 1927.

OPERATIONS

The North and South Railway operated four types of locomotives and about 82 per cent of its total tractive power in its freight service. There was no increase in its power during the years 1921 to 1927, inclusive.

On March 1, 1920, the United States Railroad Administration turned over the operations of the North and South Railway to its owners. In April of that year, the switchmen's strike, spreading eastward rapidly from Chicago, made itself felt very soon on this road. It was not until the end of 1921 that transportation conditions returned to a normal state.

Again in 1922 the results of a strike were felt on the North and South Railway. Train service was again disrupted, as is shown graphically in a chart hereafter referred to, and in 1926 the normal movement of coal was disturbed by the British Labor Strike.

Table II shows the train performance on the entire system for the seven-year period, 1921-1927. It is seen that while the traffic was steadily increasing the efficiency was practically unchanged, and not until the double tracking was completed did the efficiency increase. The results of this improvement are reflected in the system figures to a large extent, since by far the larger percentage of the traffic moved over the Northern Division. It is particularly interesting to note the increase in the number of gross ton miles per train-hour after the double tracking.

TABLE II

Year	Freight Train Hours: Hours	Freight Train Hours: Index	Hours Per 100 Freight Train Miles: Hours	Hours Per 100 Freight Train Miles: Index	Average Gross Train Load: Hours	Average Gross Train Load: Index	Gross Ton Miles Per Train Hour: G.T.M.	Gross Ton Miles Per Train Hour: Index
1921	114,108	100	10.70	100	2630	100	24,570	100
1922	114,499	100	11.15	104	2522	96	22,597	92
1923	152,634	134	11.20	105	2660	101	23,740	97
1924	168,352	148	10.83	101	2636	100	24,336	99
1925	194,699	171	10.92	102	2670	101	24,438	99
1926	149,145	131	9.04	84	2841	108	31,421	128
1927*	141,900	124	8.29	77	3100	118	37,402	152

NOTE *.—Based on year December 1, 1926-November 30, 1927.

Fig. 1 and 2 show graphically the same information as is given in Table II, with operating results for 1924 superimposed on the 1926 chart. These two charts are presented to show the relative improvement in operation that has taken place. It is interesting to note the changes from year to year. The slope line representing the average road time per train under varying traffic densities, shown on the charts, passes through the average point plotted for each year. The slope of this line is determined by pivoting the upper and lower line on the yearly average, so as to divide the monthly averages as nearly as possible, keeping the intersection of these lines with the base on the same vertical. The intersection points were established at eight hours, which requires an average speed of 12.5 miles per hour for a 100-mile run. This slope line indicates that the time of freight trains per 100 miles increases as the traffic density increases.

The effect of the shopmen's strike is shown on the 1922 chart, the months of July to December, inclusive, numbered 7 to 12, make a poor showing. The performance of the last six months of 1923 was plotted with the first six months of 1922 to correct the position of the slope line for this strike. With a traffic density of 5,000 train-miles per day, the hours per 100 train-miles decreased from 12.6 in 1921 to 12.0 in 1922, or 5 per cent.

The year 1923 shows a further increase in the traffic density with an increase in the average hours per 100 train-miles. There was, however, a slight decrease based upon the same traffic density. Compared with a density of 5,000 train-miles per day, the hours per 100 train-miles was 11.9, which was a decrease of 6 per cent compared with 1921. On this chart it was also necessary to correct for the after-effect of the shopmen's strike in 1922. This was done by plotting the first four months of 1924 in connection with the last eight months of 1923 in determining the average slope line.

The freight train performance was better in 1924 compared with previous years, as the hours per 100 train-miles decreased with an increase in traffic density. With a traffic density of 5,000 train-miles per day, the hours per 100 train-miles decreased to 11.3, or 1.3 hours, a 10 per cent decrease compared with 1921.

The improvement continued in 1925 with an increased business and only a slight increase in the hours per 100 train-miles; however, compared on a traffic density of 5,000 train miles per day, the hours per 100 train miles decreased 13 per cent under 1921.

The 1926 chart shows a very decided improvement in train performance. The traffic decreased about 3 per cent, and the time per 100 train-miles was reduced from 10.92 hours to 9.04 hours, a reduction of 17 per cent compared with 1925.

The extension of the double track was begun and completed in 1925. The improvement in operation was immediately reflected on the system chart for 1926, as indicated above, and for ease of comparison, the average road time curve for 1924 is superimposed on the 1926 chart. The 1926 chart reflects a remarkable improvement in train operation and, as shown in Table II, the gross ton-miles per hour increased over 1921, 28 per cent in 1926 and 52 per cent in 1927.

The increase in the track capacity of the system, as the result of the double-track improvement, may be measured by the perpendicular distance between the 1924 and 1926 average road time curves on the 1926 chart, Fig. 2. The point "A" shows the average hours per 100 train-miles and average trains and average train-miles per day 1924. The increase in track capacity may be determined by measuring the distance along a vertical line drawn from point "A" to the intersection of the 1926 average road-time curve. This increase, approximately 100 per cent, doubles the track capacity.

From Fig. 1 and 2 assuming an average traffic density of 5,000 train-miles per day, it can be seen that the average hours per 100 train-miles would have been 12.6 hours for 1921; 12.0 hours for 1922; 11.9 hours for 1923; 11.3 hours for 1924; 11.0 hours for 1925; 9.2 hours for 1926, and 8.4 hours for 1927. Assuming 1921 as a base for these figures, indices for the subsequent years would be: 1922, 95; 1923, 94; 1924, 90; 1925, 87; 1926, 72, and 1927, 67.

Northern Division

The Northern Division has by far the greatest traffic density of any of the three divisions. The gross ton-miles per mile of road per day in 1927 was approximately 104,200, whereas for the system, including the Northern Division, the gross ton-miles per mile of road per day was 42,200.

Business on the Northern Division increased very rapidly from 1921, as indicated in Table III. In 1924 it will be seen, the gross ton-miles had increased 60 per cent, whereas the train performance, gross ton-miles per train hour, had decreased 9 per cent. It was apparent from this situation that something had to be done to increase the traffic capacity of the division, if it was desired to handle all business offered. The extension of the double track, as shown in Fig. 3 was proposed and constructed in order to increase capacity.

As will be noted on the profile, slight grade reductions were effected at three places on the line at the time the second track was constructed. These reductions have been of material assistance in eliminating the danger of slow freight trains stalling and have made possible an increase in train load.

This increase is noted in Table III.

Table III—Northern Division

Year	Trains Run	Freight Train Miles	1,000 Gross Ton-Miles		Freight Train Hours	Train-Hours Per 100 Train-Miles		Gross Train Load		Gross Ton-Miles Per Train-Hour	
			Year	Index		Hrs.	Index	Ave.	Index	Ave.	Index
1921	6,300	737,654	2,292,445	100	70,024	9.49	100	3,108	100	32,738	100
1922	5,949	684,128	2,073,985	90	67,040	9.80	103	3,032	98	30,937	94
1923	7,969	933,978	2,932,413	128	95,084	10.18	107	3,140	101	30,840	94
1924	10,207	1,209,655	3,676,045	160	122,738	10.15	107	3,039	98	29,950	91
1925	11,844	1,386,591	4,271,356	186	144,151	10.40	110	3,080	99	29,631	91
1926	10,583	1,240,023	4,155,919	181	97,141	7.83	83	3,351	108	42,782	131
1927*	9,180	1,215,800	4,641,300	202	92,800	7.63	80	3,817	123	50,014	153

Note *.—Based on year December 1, 1926, to November 30, 1927.

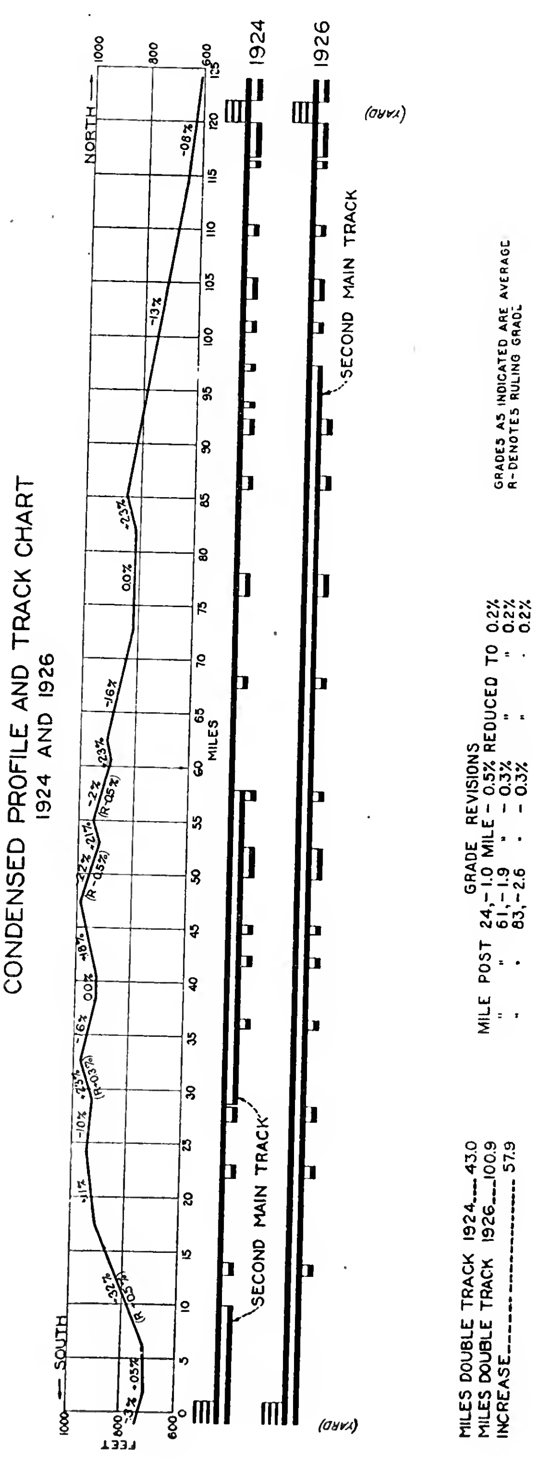

CONDENSED PROFILE AND TRACK CHART
1924 AND 1926
SOUTH
NORTH
FEET
MILES
1924
1926
SECOND MAIN TRACK
SECOND MAIN TRACK
(YARD)
(YARD)
GRADE REVISIONS
MILE POST 24,-1.0 MILE - 0.5% REDUCED TO 0.2%
" " 61,-1.9 " - 0.3% " " 0.2%
" " 83,-2.6 " - 0.3% " " 0.2%
GRADES AS INDICATED ARE AVERAGE
R-DENOTES RULING GRADE
MILES DOUBLE TRACK 1924 43.0
MILES DOUBLE TRACK 1926 100.9
INCREASE 57.9

Fig. 3

June, 1924, was taken as a normal average month prior to double tracking and has been compared in Table IV with June, 1926, and June, 1927, representing comparable months after double tracking. Attention is called to the great increase in the efficiency of operations, shown by an increased speed and increased number of gross ton-miles per crew-hour.

Fig. 4 and 5 are train-hour diagrams showing the performance of northbound slow and manifest freight trains, respectively. Superimposed on these charts are theoretical train-hour curves developed by the equation suggested by Committee XXI in Vol. 23, pages 729 and 745.

It is interesting to note the decrease in both elapsed and road-time in 1926 compared with 1924. The area within the curve indicates the total train and crew-hours. It is also interesting to note the decrease in the range between the fastest and slowest train on each diagram, indicating more regular service accompanied by increased speed.

Fig. 6 shows graphically the improvement in the average road-time of all northbound freight trains, June, 1926, over June, 1924. The slopes of these curves were determined by using values derived in the computations for the train-hour diagrams, Fig. 4 and 5. On the chart entitled "All Freight Northbound," Fig. 6, increase in the track capacity of the Northern Division, as the result of improvements, can be measured by the vertical distance between the 1924 and 1926 curves. Assuming that the track capacity of the division in 1924 was approximately 500 northbound trains per month (the actual number in June was 460), as the result of the improvements, the time saved per train, traffic density remaining the same, was 2.65 hours, or 20.3 per cent, or the track capacity northbound was increased, time remaining the same, to approximately 1,000 trains per month, an increase of 100 per cent.

As approximately the same increase in track capacity for the system was shown by the 1926 chart, Fig. 2, it follows that the traffic density on the other two divisions must be considerably less than their capacity. This is true as records indicate only four to six trains per day are operated on these divisions.

While train-hour diagrams were not developed for the southbound movement, which is largely the return of empty coal cars, the North and South Railway's increase in operating efficiency has shown up in results for southbound movement commensurate with the northbound. While the train-hours per trip northbound were being cut 2.33 hours, or 18.7 per cent, in June, 1926, under June, 1924, the southbound movement also speeded up, clipping 2.27 hours, or 22.0 per cent, from the average time in June, 1924.

Table IV shows interesting operating statistical figures comparing June, 1924, with June, 1926. Attention is called particularly to the increased train load from 3,323 to 3,676 which was further increased to 3,834 gross tons in June, 1927, and the increased speed, which resulted in an increase in the gross ton-miles per crew-hour of 38 per cent in 1926 and a total increase of 55 per cent for the three years.

Train Hour Diagram Showing Performance of Slow Freight Trains June, 1924, and June, 1926, Before and After Double Tracking

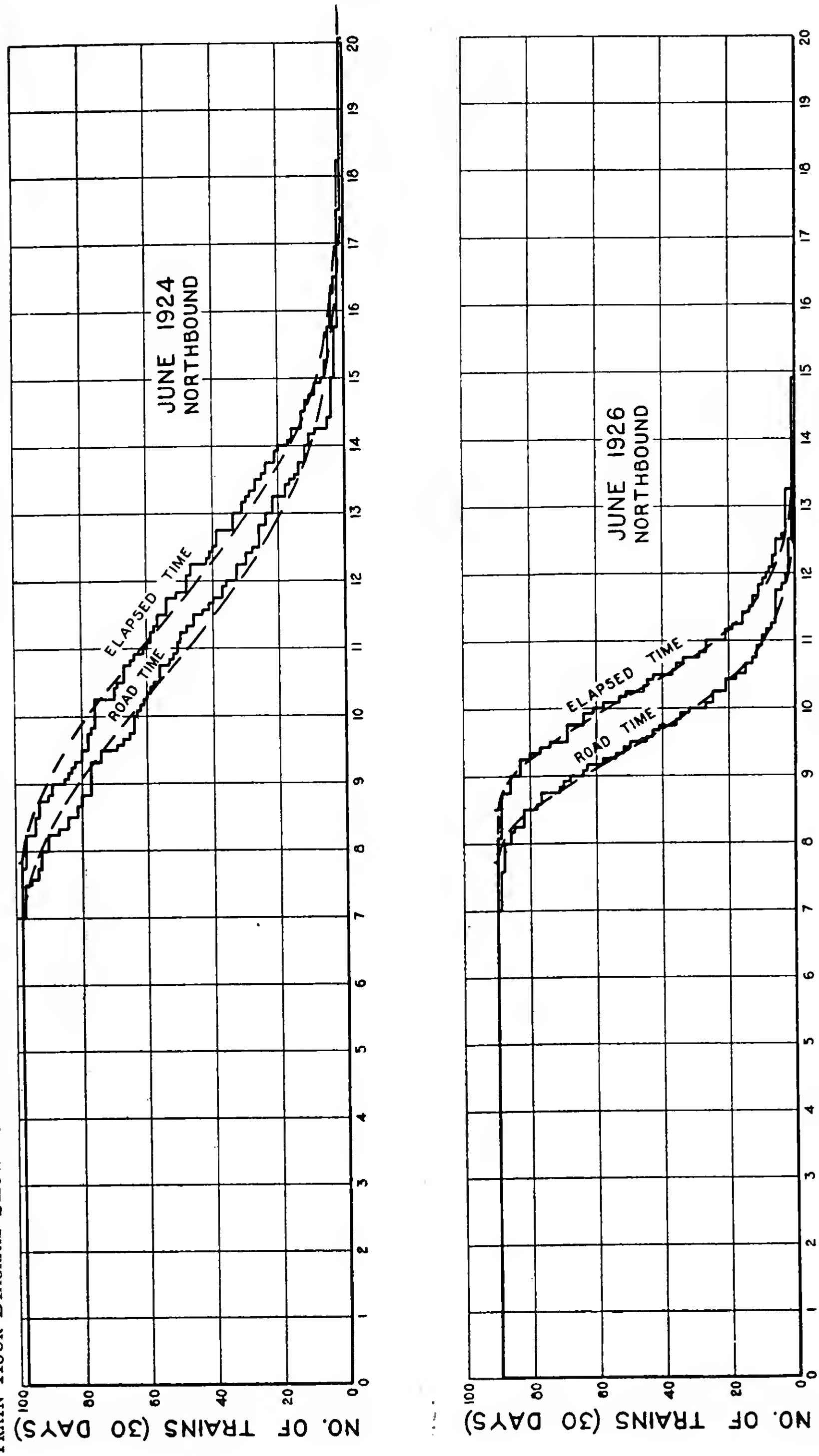
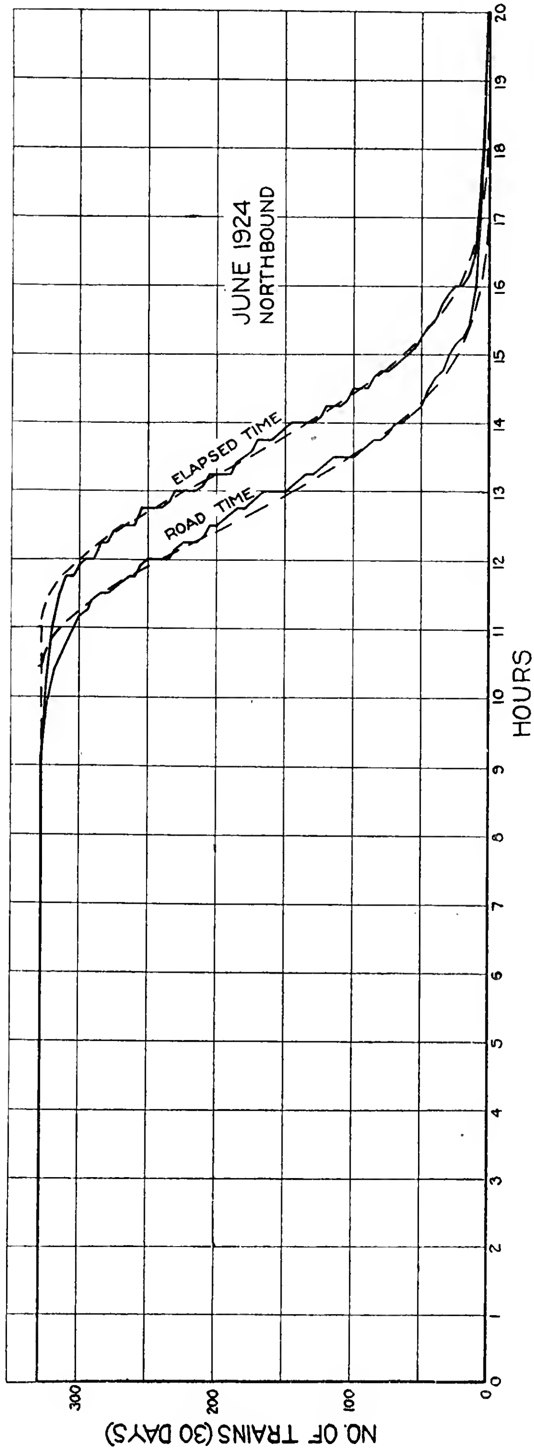


Fig. 4



Train Hour Diagrams Showing Fast Freight Trains Before and After Double Tracking

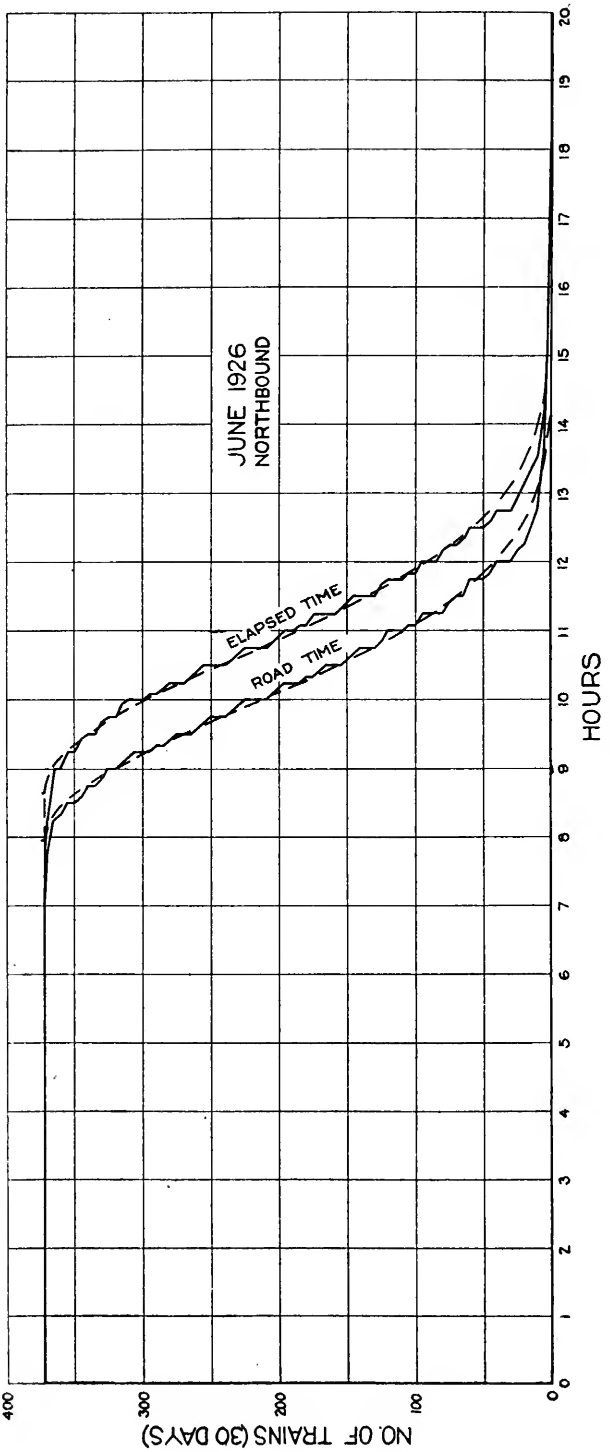

JUNE 1926
NORTHBOUND
ELAPSED TIME
ROAD TIME
HOURS
NO. OF TRAINS (30 DAYS)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
0 100 200 300 400

Fig. 5

TRAIN PERFORMANCE ON 122-MILE SECTION DERIVED FROM TRAIN HOUR DIAGRAMS NORTHBOUND TRAINS JUNE, 1924 AND 1926, BEFORE AND AFTER DOUBLE TRACKING

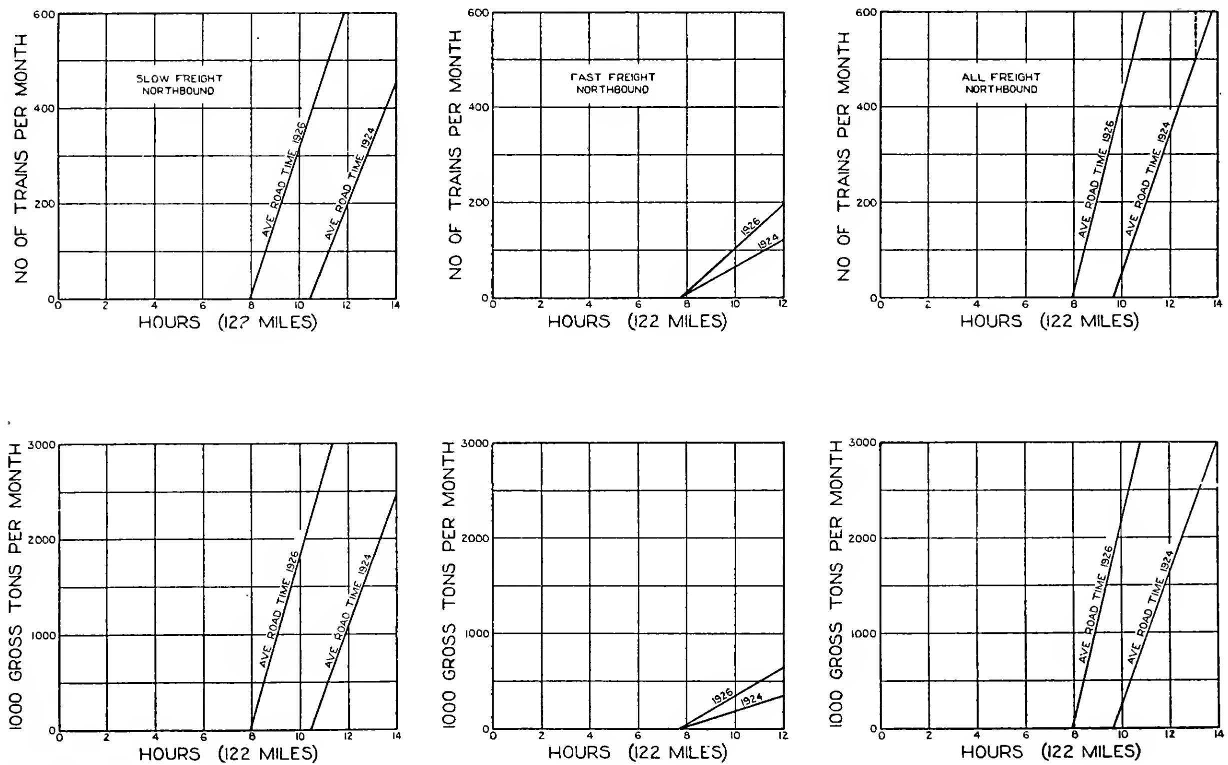


FIG. 6

Conclusion

The above analysis shows that the construction of double track along with the slight grade reductions made, practically doubled the capacity of the railway. All the increased capacity did not result from the additional track, as the grade reductions made possible an increase in loading. This increased capacity made it possible for the railway to accept all the tonnage offered and to handle same more efficiently than before double track was installed. The increase of 55 per cent in gross ton-miles per crew-hour will result in operating economies that justify the expenditures necessary to obtain this increased capacity.

Table IV—Northern Division

Freight Train Performance Before and After Double Tracking

Month of June

	Manifest			*Slow*			*Manifest and Slow*		
	1924	*1926*	*1927*	*1924*	*1926*	*1927*	*1924*	*1926*	*1927*
Number of Trains:									
South	90	90	90	346	363	393	436	453	483
North	98	90	90	346	377	404	444	467	494
Total	188	180	180	692	740	797	880	920	977
Gross Train Load:									
South	1,482	1,599	1,599	1,821	2,131	2,168	1,750	2,025	2,061
North	2,917	3,327	3,252	5,458	5,743	6,084	4,886	5,275	5,564
Average	2,230	2,463	2,425	3,626	3,973	4,155	3,323	3,676	3,834
Gross Ton-Miles Per Crew-Hour:									
South	17,304	24,789	24,813	16,876	24,881	27,698	16,950	24,881	27,209
North	34,881	38,710	40,769	47,440	62,868	71,928	43,940	58,421	66,449
Average	24,217	32,742	33,639	32,531	44,865	51,000	30,986	42,791	48,051
Road Hours Per Train:									
South	9.50	7.10	7.05	11.85	9.58	8.70	11.37	9.08	8.39
North	11.17	9.66	8.95	12.87	10.28	9.48	12.70	10.17	9.38
Average	10.37	8.39	8.00	12.35	9.93	9.08	11.93	9.63	8.89
Ave. Miles Per Road-Hr.:									
South	12.85	17.19	17.30	10.19	12.61	13.88	10.65	13.38	14.40
North	10.92	12.61	13.64	9.24	11.78	12.75	9.57	11.94	12.91
Average	11.77	14.55	15.25	9.70	12.17	13.28	10.08	13.01	13.60

Appendix B

(3) STUDY OF METHODS OR FORMULAS FOR THE SOLUTION OF SPECIAL PROBLEMS RELATING TO MORE ECONOMICAL AND EFFICIENT RAILWAY OPERATION

J. E. Teal, Chairman, Sub-Committee; E. E. Kimball, M. F. Steinberger, B. Wheelwright, J. M. Farrin, H. T. Porter, J. M. Brown, C. C. Williams, S. B. Cooper, W. J. Cunningham, V. I. Smart.

The special problem assigned to the Committee for the current year was to "Study the Effect of the Increasing Capacity of Engine Tenders on the Economical Spacing of Water Stations and the Cost of Railway Operation."

"Gross ton-miles per train-hour" is recognized as one of the most significant units in operating statistics and is a comprehensive index of freight-train operating efficiency. An increase in gross ton-miles per train-hour may be brought about by:

(1) Increasing the train load without effecting a decrease in the average speed of trains between terminals.
(2) Accelerate the train movement between terminals by eliminating stops or by increasing the speed.

Freight-train stops for water and fuel materially contribute to increasing the average time of trains between terminals and consequently to increasing the cost of train operation. Some of the items that contribute to increasing the cost of train operation because of water and fuel stops are:

(a) Wages when on overtime basis.
(b) Loss of fuel and water (1) in generating power for brakes and (2) in overcoming additional train resistance while accelerating to the original speed; in addition, the fuel lost while at stop.
(c) Wear and tear on train equipment—both locomotives and cars.
(d) Unnecessary lubrication by enginemen when at stop. Forced lubrication and drip cups will not usually be stopped when train is not in motion.
(e) Equipment rental or per diem. As the car delays increase that item of expense accrues to foreign equipment and it is reflected in decreased car utility of owned cars.
(f) Decreases utilization of locomotives with corresponding increase in investment required to handle a given volume of business.
(g) Increases the cost of locomotive and train supplies and expenses.
(h) Increases the cost of enginehouse expenses because of increased engine time between terminals. The same work can be performed with a less number of engines and consequently a smaller enginehouse force.
(i) Damage to lading account of rough handling.
(j) Delays to following freight trains.
(k) Greater cost of water and fuel handling at small installations as compared with large efficient terminal plants.

It is not practical to state all costs that result from water stops, as a number of them are intangible and may vary between wide ranges depending upon local operating conditions and traffic density.

This Committee presented a formula, or method, of determining the cost of stopping and starting trains which was published as Appendix B, page 473, Vol. 28 of the Association Proceedings. Subsequently, it was reduced to abbreviated form and authorized to be printed in the Manual of Recommended Practice.

Delays to heavy tonnage freight trains at water and fuel stations embrace:

(a) Time required to decelerate and accelerate to the original speed.
(b) Time at stop taking water and/or fuel.
(c) Time required to cut-off engine (when necessary) in order to spot at water and fuel stations.
(d) Time often necessary to cut train at grade crossing.
(e) Additional time required (which may not be necessary) to lubricate engine and pump up air line.
(f) In addition to the direct increase in costs incident to stops for water and fuel, the slower speeds may be reflected in less attractive service to shippers with a resulting loss in gross receipts.

On the other hand, the following losses result from the use of heavier tenders:

(1) Additional weight in the tender diminishes by so much the pay freight that the locomotive will haul. This loss, however, may be fanciful rather than actual, as the elimination of a water stop at the foot of a limiting grade may permit an increase in train load that will more than offset the increased weight of tender and its lading.
(2) Greater wheel concentrations cause greater damage to track and track structures.
(3) Fixed, as well as operating, expenses for tenders are increased.

These items of delay, of course, will vary according to the local conditions. Where water and fuel is taken in connection with regular station stops the time lost in deceleration and acceleration will not usually be affected, but other delays will often be affected.

In order to utilize an available source of supply, the water station is often located at the foot of a grade. That location amplifies the delay further because of the difficulty of accelerating the train to its original speed. This also results in greater wear on train equipment in stopping and greater loads on drawbars in starting, which often results in break-in-two's, in addition to increased fuel and water consumption.

Quoting from Appendix K, report of Committee XIII—Water Service, for 1928:

> "In addition to the economies in train operation through reduction in stops for water, there will also be an additional saving in elimination of water station cost where such stations may be abandoned. The actual power cost for furnishing the water used will be only slightly changed, but the fixed charges such as labor and attendance, together with the maintenance costs of the abandoned station will be eliminated. The longer runs should also permit a better selection as to quality of the supply which should prove advantageous in many cases."

A study of available printed matters reveals that there is very little authentic information to be had on this subject; therefore, in order to have the advantage of the latest data concerning the most recent development in the use of large engine tanks, including the corresponding re-spacing or elimination of water and fuel stations, a questionnaire was sent to the chief operating officers of a number of important railways which have obtained operating economies from such changes in equipment and railway facilities.

A copy of this questionnaire follows:

1. (a) What is the greatest water and fuel capacity of locomotive tenders in service?
   (b) When were tenders of large capacity placed in service?
   (c) Water and fuel capacity of tenders replaced?
2. (a) Maximum and minimum distance between water and fuel stops with tenders of large capacity?
   (b) Maximum and minimum distance between water and fuel stops with tenders replaced?
   (c) Number of water and fuel stops eliminated by the use of tenders of large capacity per engine district?
3. (a) Length of engine district on which tenders of large capacity are operated?
   (b) Average tonnage freight train load?
   (c) Ruling grade for engine district?
   (d) Tractive effort of engines used?
4. Savings account of eliminating water and fuel stops (for each stop eliminated).
   (a) Hours of crew time?
   (b) Pounds of coal?
   (c) Gallons of water?
5. What, if any, special operating difficulties have been eliminated by the use of tenders of large capacity?
6. Other items of general interest relating to this problem?

Replies to the questionnaire were received from ten railways, having an aggregate of 47,920 miles of road. Four of these railways were located with lines in the Eastern Region, three in the Southern Region, and three in the Western Region. The replies to each individual question were not complete; however, a summary has been prepared which will indicate the trend of what has been done by these roads in the way of increasing the size of engine tenders on some of their engine districts.

Three of the railways furnished information concerning increased capacity of tenders used in passenger train service. As passenger service conditions are not comparable with freight service conditions this data has been omitted from the compilation following.

In reply to Questions 5 and 6, the following information was received:

First Railroad:

Has eliminated water stops with the resulting congestion at water stations, which results in a higher percentage of useful service of freight locomotives as coal and water stops interfered with the loading and handling of locomotives to the same extent as any other delay. Has eliminated an average of three relief crews per day on account of hours of service and assists in maintaining a better train performance.

Consideration is being given to what further economies can be accomplished by use of still larger tenders than those in use.

SECOND RAILROAD:

Eliminates coal stops, which relieves blockade and delay to passenger and merchandise trains and side tracking of freight trains in order to take coal in between passenger train arrivals. Eliminates stops and blocking of highway and railway crossings. Eliminates stop at foot of hill, enabling freight trains to get good momentum and saving 25 seconds to 30 seconds in time, which means an hour or more longer on road between terminals account not being able to make meeting points. Dispatcher is able to make better meeting points with trains on single track and get them over the road with less delay.

Eliminating coal stop saves money in stopping, saves in the handling of coal, reduces the cost of handling by reducing forces, saves the long haul of coal to coal chutes, saves in time of train delays and keeps coal cars in service. Power turns faster due to getting engines over the road more promptly.

THIRD RAILROAD:

No remarks.

FOURTH RAILROAD:

Large tenders have helped to relieve congestion, speed up operation to meet present day demands on the service and cut operating expenses. It should not be overlooked that there are certain complications in attempting to compare large tenders with small tenders, of which the following are enumerated:

The small tenders were in some cases attached to smaller locomotives than were the large tenders. Distances between coal and water stops are often affected by location of division terminals, coaling plants and track pans, ascending or descending grades, class of freight handled and numerous other operating conditions.

FIFTH RAILROAD:

Operating efficiency increased as a result of eliminating stops for water and coal, as well as the possibility of drawheads being pulled out.

SIXTH RAILROAD:

Run No. 1. The length of engine district is 112 miles, with ruling grade westbound of 0.23 per cent, eastbound 0.70 per cent. Engines having a tractive effort of 103,500 lb., with 12,000 gallon capacity tenders, handle 9,000 actual gross tons or more in the westbound, or loaded, direction, making from three to five water stops, the average delay per train being 1 hour 15 minutes. Equipped with 16,000 gallon tenders, the same locomotives make the same run with a maximum of two stops; very often only one stop is necessary. The record shows a delay of 43 minutes; the saving account of elimination of water stops on this district being 32 minutes. For the eastbound movement the saving account of elimination of water stops is 22 minutes per train, the average number of stops with the 12,000 gallon capacity tenders being 2.4 per train and with the 16,000 gallon capacity tenders it is 1.1 per train.

Run No. 2. The length of engine district is 113 miles, with ruling grade eastbound of 0.20 per cent, westbound 0.50 per cent. Engines of 67,700 lb. tractive effort handle in the eastbound direction train loads of 7,500 actual gross tons, making an average of two stops between terminals, aggregating 16 minutes per stop, or 32 minutes per train. Engines equipped with 16,000 gallon tenders make only one stop of 19 minutes, the saving in time with the large tenders being 13 minutes per train. In the westbound direction the average number of stops with the small tenders was 3 of 13 minutes each, compared with 1 stop of 14 minutes with the large tenders, the actual saving in time being 25 minutes per train.

The average time of trains between terminals, handled by locomotives equipped with 16,000-gallon tenders is 6 hours 32 minutes, compared with 7 hours 11 minutes between terminals when the same locomotives are equipped with 12,000-gallon tenders, the saving being 39 minutes per train.

From the above it may be concluded that with the elimination of water stops, other delays will be eliminated, permitting a better movement from terminal to terminal. The savings account of elimination of these delays is substantial, when considering the cost of operating these heavy tonnage trains.

Seventh Railroad:

Large tenders have had an influence upon reduction in break-in-two's due to reduction in number of stops; have lessened time on the road and increased train load.

Eighth Railroad:

Possible to operate manifest freight trains over an entire division without making special stop for water.

Large tender second in importance only to the superheater as a locomotive appliance which pays the greatest returns in its operation.

Ninth Railroad:

Expedites train movement by permitting a more uniform speed and better meeting points. Reduces damage due to rough handling incidental to stops for water. In addition to the savings in fuel and water and the improvements in train operation, the use of large tenders permits, in many cases, passing up water stops where water is unsatisfactory or where grades make starting tonnage trains difficult. In some cases additional tonnage can be handled and in general, earlier arrival at destination is effected. Some water stations have been discontinued.

This railroad recently put in practice on some engine districts, the use of a 10,000-gallon tank car connected to some locomotives in freight service. The results in increased savings and improved train movement have been very satisfactory and an ultimate development of the plan will permit the discontinuance of more water stations.

Tenth Railroad:

The length of engine district is 123 miles. The ruling grade northbound is 0.25 per cent with a helper grade of 0.50 per cent, and southbound is 0.50 per cent. Locomotives have a tractive effort of 75,000 lb. They are equipped with tenders of 9000 gallons capacity. The average train load northbound is 7500 tons, southbound 2200 tons. Purchase of engine tenders having a capacity of 21,500 gallons is pending.

In order to determine the effect of using large engine tenders in train operation on this district, tests were conducted during both winter and summer months, using tenders of both 16,000 and 21,500 gallons capacity. These tests indicate that with the 21,500-gallon capacity tenders, four water stops will be eliminated northbound and three southbound. The average delay per train eliminated being 114 minutes northbound and 51 minutes southbound in winter, and 60 minutes northbound and 46 minutes southbound in summer. In addition, it is estimated that 4 water stations may be retired.

In discussing the advantages of using engines with tenders of large capacity as compared with tenders of small capacity, with the same class of power, a superintendent of one of the railroads referred to describes the situation embracing the operation over a 110-mile engine district having ruling grades in each direction slightly in excess of 1 per cent.

This engine district was originally equipped with eight water stations. When it was operated with small saturated consolidation engines all of these stations were necessary. The engines were equipped with tenders of 6000 and 7000 gallons capacity. The consolidation engines were replaced with small compound Mallet engines having tenders of 9000-gallon capacity. It was necessary for these engines to take water four times between terminals.

The Mallet locomotives were then replaced with Mikado locomotives, tractive power 60,300 lb. and with booster 71,000 lb., having the same tender capacity. The size of these engines and their water consumption proved to be out of proportion to the capacity of their tenders, which resulted in not materially improving the operation. Mikado locomotives of the same tractive power with engine tenders of 12,000-gallon capacity were then transferred to this district with result that another water station could be eliminated. A second water station can be eliminated as soon as a dependable water supply has been obtained at another station. This will be done in the near future, leaving three water stations for the entire district instead of the original eight. The Mikado engines now operated on this district with the 12,000-gallon capacity tenders show a saving of at least 35 minutes per train between terminals, as compared with engines having 9000-gallon capacity tenders.

In summing up, this superintendent states that while the improved operation came with the large engine tanks there were other improvements in operation which resulted from the use of the "19" order, improved track conditions, improved condition of power with superheater and other improved appliances that should be given due credit.

Mikado locomotives with 16,000-gallon capacity tenders can be operated on this district with but one water stop. This argument is largely in favor of adequate water capacity; however, one should not lose sight of the inability to load engines so that their capacity between hills can be utilized. If this were possible, doubtless the economic location of water stations might be materially changed.

The detail of information furnished by the various railroads that replied to the questionnaire shows:

1. Railroads have been changing from small to large engine tenders since 1918. The greater number of changes were in 1926 and 1927. Engine tenders having capacity of from 7000 gallons to 12,000 gallons were replaced with larger tenders. The largest tender in service has a capacity of 21,700 gallons of water and 26 tons of coal. Other sizes range from 10,000 gallons water capacity and from 18 to 24 tons of coal.

2. Larger engine tenders effected an increase in the average maximum distance between water stops of from 37 miles to 61 miles, or 73 per cent. The average minimum distance between water stops increased from 16 miles to 35 miles or 119 per cent. The average maximum distance between fuel stops increased from 69 miles to 102 miles, or 48 per cent. The average minimum distance increased from 53 miles to 58 miles, or 10 per cent.

3. The average number of water and fuel stops eliminated by the use of large tenders was 2.7 and 1.4, respectively, for each engine run.

4. The average length of engine district in the study is 150 miles.
5. Average freight train load—4550 tons.
6. Average tractive power of locomotives—85,500 lb.
7. Average time saved per water stop—26 minutes.
8. Average time saved per fuel stop—19 minutes.
9. Average pounds of fuel saved per water stop—910.
10. Average gallons of water saved per water stop—770.

Since the above data was compiled additional information has been received from a railway operating 2700 miles of road. This railway reports that tenders having 9000-gallon water capacity and 16 tons of coal were replaced in December, 1927, by tenders having 16,000 gallons water capacity and 24 tons of coal. These engines are used on eight freight divisions ranging in length from 82 to 140 miles. The increased tender capacity has made possible the elimination of one stop for coal and from one to two stops for water, resulting in:

	Minimum	Maximum	Average
Train-hours saved per stop (mins.)	15	40	26
Fuel saved per stop (lb.)	500	1000	850
Water saved per stop (gal.)	350	1200	756

It is the opinion of the operating officers of this road that this change has resulted in:

(a) Less time between terminals for all trains with attendant economies in the various items of operating expenses.
(b) Improving the service to patrons.
(c) Reduction in damage to equipment in starting and stopping heavy freight trains.
(d) Economies account abandonment of pumping and fueling stations, avoiding use of expensive and unsatisfactory water and securing water where most economical or desirable.
(e) Locomotives arrive at terminals with fires in better condition and require less servicing when fewer stops are made.

This report is presented as information, with the recommendation that the subject be reassigned to the Committee next year for a final report.

Questionnaire on Large Capacity Engine Tenders, 1928

	No. of Freight Runs	QUESTION NO. 1 Large Water Gals.	Large Coal Tons	Date of Change	Small Water Gals.	Small Coal Tons	QUESTION NO. 2 Miles Between Stops With Large Tenders Water Max.	Water Min.	Coal Max.	Coal Min.	With Small Tenders Water Max.	Water Min.	Coal Max.	Coal Min.	Stops Eliminated Water	Coal	QUESTION NO. 3 Miles Per Trip	Gross Train Load	Ruling Grade	Engine Tractive Power	QUESTION NO. 4 Saving Per Water Stop Eliminated Time - Minutes Max.	Min.	Avg.	Water Gals.	Coal Lbs.
First Railroad Eastern Region	3	11000 and 12000	18½	8-1926 to 10-1926	9000 to 10000	15½ to 18½	53 to 131	34 to 50	76 to 107	50 to 107	42 to 51	12 to 19	54 to 107	40 to 107	1 to 3	0 to 2	131 to 280	3500 to 10500	.30 to 1.00	64550	30	15	23	146 to 1445	219 to 1700
Second Railroad Western Region	11	21500	24	12-1927	12000 to	20	38 to 83	19 to 63	70 to 245	54	28 to 57	8 to 40	40 to 66	24	1 to 4	0 to 2	52 to 406	2079 to 7500	.00 to 1.25	90000	75	10	30	200 to 1400	400 to 2000
Third Railroad Western Region	1	21700	-	1925	10000	-											218	12500	.20	95500					
Fourth Railroad Eastern Region	8	15000	18 to 24	1922 to Date	7500 to 10000	12 to 16	80	43	150	64	25	15	134	16	1 to 3	- -	63 to 187	1777 to 6260	.15 to .86	48570 to 78170	-	30	-	1200	1700
Fifth Railroad Southern Region	1	15000	20	1926	12000	16	60	29	65	35	40	12	65	35	1 to 2	0 to 1	100	5865	.87	69400 to 81400	15	10	12	600 to 1000	600 to 1000
Sixth Railroad Southern Region	2	16000	20	Still	12000	15	42 to 84	20 to 55	67 to 109	47 to 109	28 to 55	14 to 27	67 to 109	47 to 109	1 to 3	0 to -	112 to 113	2350 to 9000	.20 to .70	67700 to 103500	32	13	22	-	-
Seventh Railroad Southern Region	3	16000 and 18000	23 and 26	8-1924 9-1927	9000 to 12000	14 to 20	37 to 61	24 to 52	61 to 100	32 to 100	20 to 31	5 to 16	61 to 68	32 to 52	2 to 5	0 to 1	100 to 113	2000 to 9500	.30 to 1.60	107373 to 109286	109	8	- These figures show maximum and minimum difference in time on road since operation of large tenders, however, not all of this saving can be said to have resulted from installation of large tenders.		
Eighth Railroad Eastern Region	1	15000	18	1924 to 1928	10000	16	100	25	100	32	90	-	51	-	1 to 4	0	148	5000	.30 to 1.00	66000 to 78150	-	-	15	600	1000
Ninth Railroad Western Region	2	10000	25 coal 4000 oil	1918 to 1920	8000	18	61	15	179	38	42	15	105	38	2		84 to 198	2400	1.10 to 1.55	64000	30	15	22	375 to 1500	150 coal to oil
Tenth Railroad Eastern Region	1	21500	24	-	9000	21	83	51	-	-	30	10	-	-	3 to 4	-	124	2500 to 7500	.25 to .50	74000	35	8	21	400 to 1914	250 to 1195

Appendix C

(4) STUDY OF THE MOST ECONOMICAL MAKEUP OF TRACK TO CARRY VARIOUS TRAFFIC DENSITIES

No work done on this account of waiting until Committee IV—Rail reports upon economics of the different sizes of rail.

Appendix D

(5) STUDY OF SUITABLE UNITS FOR OPERATING AND EQUIPMENT STATISTICS REQUIRED BY INTERSTATE COMMERCE COMMISSION TO BE USED IN COST COMPARISONS OF TRANSPORTATION, EQUIPMENT AND ROADWAY MAINTENANCE WITH NECESSARY ADDITIONS THERETO

F. H. McGuigan, Chairman, Sub-Committee; G. D. Brooke, M. L. Byers, H. C. Crowell, W. J. Cunningham, L. E. Dale, L. E. Little, M. F. Mannion, H. T. Porter, C. H. Stein, C. C. Williams.

Sub-Committee reports progress and requests that subject be reassigned for final report next year.

Appendix E

(6) STUDY OF WHAT VOLUME OR OTHER CONDITIONS OF BUSINESS OR SERVICE JUSTIFIES A CHANGE FROM FLAT SWITCHING TO THE HUMP METHOD IN ANY GIVEN YARD

J. F. Pringle, Chairman, Sub-Committee; B. T. Anderson, L. E. Dale, J. M. Farrin, G. F. Hand, E. M. Hastings, T. C. Nacnabb, L. S. Rose, R. T. Scholes, B. J. Schwendt, C. H. Stein, M. F. Steinberger.

The Committee last year submitted as information a summary of answers received to a questionnaire on hump yard operation. This year detailed information as to the operation of a number of hump yards with both car riders and car retarders was obtained. A summary of this data is submitted as information.

From a study of this and other information, the Committee is of the opinion that conditions as to number of classifications, ratio of cuts to total cars handled, time element and physical conditions are so varied that a definite answer in terms of volume and conditions is not possible, but that limits within which detailed study of the advantages of changing from flat to hump switching would be justified can be indicated and methods to be followed in making such a study outlined.

A change from flat to hump switching is rendered desirable by:

(1) Increase of volume beyond the ability of a flat yard to handle.
(2) Necessity of increased speed.
(3) Economy of operation.

The volume of business as measured in cars handled in and out of a yard in itself is not the determining factor unless accompanied by a definite number of classifications and a certain ratio of cuts per 100 cars handled and, will also depend upon whether or not continuous operation is necessary.

The possibilities of improved service and economy in operation by a change from flat to hump switching should be studied when any or all of the following conditions are present:

(1) The number of cars received and classified continuously over the 24-hour period exceeds 800.
(2) The number of classifications regularly made exceeds 10.
(3) The ratio of classifications exceeds 1:5, i.e., over 20 cuts per 100 cars.
(4) Necessity for increased speed of operations.
(5) Over 20 per cent cars handled to be weighed.

The cost of hump yard operation is divided into five (5) elements:

(1) Supervisory and clerical.
(2) Engine service.
(3) Car riders or retarder operators.
(4) Maintenance of increased facilities.
(5) Interest on increased facilities.

Supervisory and Clerical

This feature of cost would be the same under either flat or hump switching except that there is a possibility of reduced cost in hump switching if the operation is not continuous, but for purposes of comparison may be considered the same.

Engine Service

The number of cars which can be brought from a receiving yard and classified over a hump depends upon:

(a) The number of riders assigned and the facilities provided for return to the hump.
(b) Number of cars per train and number of cars per cut.
(c) Design of yard with special reference to speed with which cars will clear the lead. The range is from 50 to 100 cars per hour and for purposes of study may be taken as 75.

The number of switch engines required per 8-hour shift depends upon the number of cars and with over 600 cars per 8-hour shift, an engine will be required for hump service and a second for trimming and making up trains. Where the volume is light the work may be divided, the same engine doing both the humping and trimming.

The number of eight-hour shifts required depends upon the number of cars to be humped and the necessity for continuous operation. If continuous operation is necessary, the minimum number of shifts required is three

Questionnaire on Hump Yard, 1928

Description	Yard "F"	Yard "G"	Yard "H"	Yard "1"
	Intermediate Terminal Retarder Equiped	Intermediate Yard Car Riders	#1 Humpyard Operated by Car Riders	Flat Yard
A			North / South	Flat Yard where freight is received and delivered to 2 Con. Rds. Separate tracks not set aside for receiving or classification or as departure but used for all these purposes as necessary
1. Number & Length of Receiving Tracks	15 - 100 Cars Each	7 - 146 Cars Each	North: 19 Tracks, 32 to 76 Cars; South: 13 Tracks, 35 to 74 Cars	
2. Number of Tracks over Hump	One	One	North: 2; South: 1	
3. Number & Length of Classification Tracks	25 - 100 Cars Each	21 - 99 Cars Each	North: 46, 17 to 60 Cars; South: 29, 19 to 72 Cars	
4. Number & Length of Departure Tracks if Separate from Classification	14 - 145 Cars Each	16 - 91 Cars Each	North: 3, 46 to 54 Cars; South: 3, 33 to 50 Cars	
B 1. Number of Trains Received in 24 Hrs.	31	17	Handles daily 3600 to 6000 cars (2 count) principally high-class & perishable freight Avge. 30 to 60 from each direction	29.4
2. Number of Cars Received in 24 Hours	1549 50 per Train 774 per Shift (2 Shifts Workd)	821 50 per Train 273 per Shift (3 Shifts Worked)	1800 to 3000 principally high-class & perishable	1351
3. Number of Classifications Made	32	30	North 39; South 29	24
4. Number of Cars for Each Classification	4 to 250 Average 51	1 to 100 Average 27	Seasonal 6 to 200	2 to 430 Average 56
5. Number of Cuts per 100 Cars	72 1.39 Cars per Cut	76 1.3 Cars per Cut	80 1.26 Cars per Cut	17.8 5.6 Cars per Cut.
6. Average Length of Time from Arrival to Departure of Cars	17 hr. 30 mins.	12 Hr.	Perishable 7 Hrs. Dead 17 "	6 Hrs.
7. Is Operation Continuous over 24 Hrs.	No. 8 AM to 4 PM and 8 PM to 4 AM	Yes	Yes, both Humps	Yes
8. Number of Trains Dispatched in 24 Hours	20	42	40 to 60	30
9. Are Cars Ridden to Coupling	No.	No.	Yes.	-
10. Is Switching Done at One or Both Ends of Yard				Both

			[illegible] Hump as well as handling Bad Order Cars to and from Shop Track, Hold Tracks, etc. 17 divided up in handling BULK and LCL Transfer Car, Bad Order Equipment Classification making up Trains and Industrial Work, etc.	1.4 Shop Tracks.
2. Number of Men in Engine Crews (Incl. Ground Crew and Total Wages) per 8 Hour Shift.	2 Enginemen 2 Firemen 1 Conductor 1 Brakeman $ 46.88	1 Enginemen 1 Fireman 1 Conductor 1 Brakeman $30.32	29 Enginemen) $118.30 29 Firemen) 7 Conductors 49.98 14 Brakemen 91.68 $259.96 (Condtrs. & Brakemen in Flat Surface Swtch'g & Total Wages per 8 Hr. Shift.)	1 Engineman $ 6.88 1 Fireman 6.40 1 Foreman 7.14 2 Helpers 13.24 $32.86
3. Number of Car Riders per 8 Hour Shift and Total Wages per 8 Hour Shift (Retarder Operators if Used)	3 Retarder Operators $ 23.82	13 Brakemen $ 86.06	8 to 20 Riders per Hump Crew $ 193.02	None
4. Number & Wages of Yardmasters, Asst. Yardmasters, Clerks, Checkers, etc per 8 Hour Shift	1 Yardmaster 1 Clerk, 1 Checker 2 Maintainers $ 31.34	1 Clerk, 1 Checker 1 Maintainer $ 16.35	1 Gen.Yardmaster $ 10.71 3 Asst. " 25.71 15 Clerks 80.32 $116.74	11.6 Men $73.20 per Eight Hour Shift
5. Number of Switchtenders and Skatemen and Total Cost per 8 Hour Shift	2 Switchtenders 1 Skateman $ 16.06	2 Switchtenders $ 10.14	1 Electrical $ 5.20 4 Handthrow 20.28 $ 25.48	None
6. Number of Tons of Coal per 8 Hour Shift.	12 Tons $29.22	8 Tons $ 14.61	26 1/3 Tons $106.64	3 Tons @ $3.57 - $10.71
7. Cost of Water, Lubricants & Other Locomotive Supplies per 8 Hour Shift	$1.94	.97¢	$51.75	94.3 ¢
8. Total Cost per 8 Hour Shift	Engine Crew $ 46.88 Retarder Operators 23.82 Yardmasters, etc 31.34 Switchtenders 16.06 Total Wages $118.10 Coal & Supplies 31.16 Total.......... $149.26	Engine Crew $ 30.32 Riders 86.06 Yardmasters, Etc 16.35 Switchtenders 10.14 $142.87 Coal & Supplies 15.58 Total.......... $158.45	$269.36 193.02 116.74 25.48 $595.20 Coal & Supplies 157.39 Total.......... $752.59	32.66 x 16.4 - $ 535.62 73.20 x 3 - 218.60 Total per 24 hrs $ 754.22 Coal & Supplies $ 191.06 Total per 24 Hrs $ 945.28
9. Cost per Car Single Count	19.3	58.0	72.12	70
10. Cost per Car Wages Only	15.3	52.4	57.2	56
11. Cost per Car Wages, Switching Only				
12. Cost per Car, Supervision				

Questionnaire on Hump Yard, 1928

	Yard "A"	Yard "B"	Yard "C"	Yard "D"	Yard "E"
Name of Yard					
Description	Intermediate Terminal Humpyard Retarder Equiped	Intermediate Terminal Car Riders	Intermediate Terminal Eastbound Yard Hump with Retarders Westbound Yard Flat	Retarder Yard	Intermediate Terminal Retarder Operated
A.					
1. Number & Length of Receiving Tracks	21 - 76 Cars Each	19 - 70 Cars Each	9 - 106 Cars Each	13 - 81 Cars Each	5 - 50 Cars Each
2. Number of Tracks Over Hump	2 (North & South Hump)	2 (North & South Hump)	One	One	One
3. Number and Length of Classification Tracks	59 - 71 Cars	59 - 64 Cars	30 - 74 Cars	26 - 76 Cars Each	24 - 56 to 62 Cars Each
4. Number & Length of Departure Tracks if Separate from Classification Tracks	5 - 112 Cars	5 - 112 Cars	3 - 114 Cars	None. Trains depart from Classification Tracks	None
B.					
1. Number of Trains Rec'd in 24 Hrs.	55	42	37.6	16	24
2. Number of Cars Rec'd in 24 Hrs.	2432 44 per Train 811 " Shift	1911 46 per Train 640 " Shift	3106 82 per Train 1033 " Shift	1275 of which 925 are Humped	848 35 per Train 282 " Shift
3. Number of Classifications Made	45	45	28 (Eastbound Yard)	24	47
4. Number of Cars for Each Classification	Varies from 8 to 168 Average 54	Not available	Varies from 18 to 150 Average 111	50	Varies from 1 to 88 Average 18
5. Number of Cuts per 100 Cars	65 1.54 Cars per Cut	" "	71 1.41 Cars per Cut	70 1.45 Cars per Cut	65 1.54 Cars per Cut
6. Avge. Length of Time from Arrival to Departure of Cars	13 Hours	" "	8.7 Hrs. Dead Freight & Empties. Perishable not Included	8 Hours	$10\frac{1}{2}$ Hours
7. Is Operation Continuous over 24 Hrs.	North Hump Yes, Except when 16 Hrs. are Worked South Hump No. Total Time for June 404 Hr. 15 Mins. 13.4 Hrs. Per Day	Yes Except South Hump where 19 Days were worked out of 31	Yes	No. 1 Ten Hr. Shift with Overtime Average 10.4 Hrs. per Day	Yes
8. No. of Trains Dispatched in 24 Hrs	53	45	44.4	15	20
9. Are Cars Ridden to Coupling	No. Retarders used both Humps	Yes	No. Retarders used. Flat Switching Westbound Yard	No. Retarders used	Car Retarders

	3 Westbound Engines making up Westbound Trains etc 2 Misc. Swtg. Hold Tracks, etc Total 12 Engines Per Shift 4 "	3 South Yard making East & Southbound Trains and Misc. Work Total 16 Engines Per Shift 5 "	4 Hump Total 11 Engines Per Shift 3.66 "		[illegible] Total 6½ Engines Per Shift 2.26 "
2. Number of Men in Engine Crews (Incl. Ground Crew) and Total Wages per 8 Hour Shift.	20 Men $136.40 per Shift	25 Men $169.25 per Shift	18 Men $121.86 per Shift	Enginemen $ 8.20 Firemen 6.42 Foremen. 7.14 3 Helpers 19.86 $41.62	Practicelly 6 Each Wages in 24 Hrs $ 236.78 " " 8 " 78.93
3. Number of Car Riders per Eight Hour Shift & Total Wages per Eight Hour Shift (Retarder Operators if Used)	6 Retarder Operators $ 47.64	20 Riders $132.40	6 Retarder Operators $ 39.70	5 Retarder Operators $ 38.41	3 Car Riders per Shift 3 Retarder Operators per Shift Wages in 24 Hr. $ 131.04 " " 8 " 43.68
4. Number & Wages of Yardmaster, Asst. Yardmaster, Clerks, Checkers, etc per 8 Hr. Shift	10 Men $ 77.59	10 Men $ 81.19	10 Men $ 70.77	1 Yardmaster 9 Clerks & Checkers 10 $ 55.61	Total Force 34 24 Hr. Wages $157.95 Chargeable this Yard 24 Hrs. $110.52 8 " 36.84
5. Number of Switchtenders & Skatemen and Total Cost per 8 Hr. Shift	6 Men $ 27.49	12 Men $ 60.84	1 Man $ 5.07	None	None
6. Number of Tons of Coal per 8 Hour Shift and Cost.	16.73 Tons $ 54.46 4.11 Tons per Engine Shift	12.75 Tons $ 48.96 2.55 Tons per Engine Shift	14.83 Tons $ 48.27 4.1 Tons per Engine Shift	6 Tons @ $2.05 - 12.30 $ 1.54 per Engine Hr.	2 Tons per Engine Shift 54 Engine Hours 49.95 6 " " 16.65
7. Cost of Water, Lubricants & Other Locomotive Supplies per 8 Hr. Shift	$ 7.96 $ 2.00 per Engine Shift	$ 3.90 .74¢ per Engine Shift	$ 7.16 1.99 per Engine Shift	$ 1.20 per 8 Hr. Shift .15¢ per Engine Shift	.04 per Engine Hr. 2.16 per 24 hrs.
8. Total Cost per 8 Hr. Shift	Eng. & Crew Wages $ 135.40 Retarder Operators 47.64 Yardmastors etc 77.59 Switchtenders 27.49 Total Wages $ 288.12 Coal & Supplies 62.22 Total $ 350.34	Eng. & Crew Wages $ 169.25 132.40 81.19 60.94 $ 443.68 52.35 $ 496.53	Eng. & Crew Wages $121.86 Per 8 Hr. Shift 39.70 70.77 5.07 $237.40 55.43 $292.83	7 Months Cost Total Eng. Crew $ 12303.16 Retarder Operators 8862.13 Yardmst & Clks 11678.95 Total Wages $ 32844.24 Coal & Supplies 3736.59 Electricity 700.00 Maintenance of Retarders 15592.08 Total $ 52872.91 Cars Humped (Single Count) 193576	Per 24 Hours $ 236.78 " " " 131.04 " " " 110.52 Total $478.34 52.11 Total $530.45 Per 8 Hr. Shift 176.82
9. Cost per Car (Single Count)	43.2	77.6	28.27	27.3	62.5
10. Cost per Car Wages Only	35.5	69.2	23.0	16.5	56.4

(3) and will vary depending upon the number of cars to be humped.

Crew and Wage Costs

The number of men in the crew in practice varies from two, engineer and fireman, to 6, engineer, fireman, foreman and three (3) helpers, but the usual crew is five (5), engineer, fireman, foreman and two (2) helpers, and wage cost is approximately $34.00 per shift. The fuel and other cost may be taken from available records for flat switching.

Car Riders

The number of cars handled per car rider per shift varies with the length of the classification yard, etc., ranging from 30 to 60 with an average of 45. Car riders are generally paid current wages for switchmen.

The number of retarder operators depends upon the design of the yard but for estimating purposes may be assumed at 4 per shift and wage cost of $31.20 per shift.

Maintenance

There is very little if any difference per mile of track for track maintenance as between flat and hump yards, but when retarders are used there is an increase in the cost of maintenance.

Interest

Interest on the total outlay should be allowed for at the current rate.

Appendix F

(7) STUDY OF PROBLEMS OF RAILWAY OPERATION AS AFFECTED BY THE INTRODUCTION OF MOTOR TRUCKS AND BUS LINES, WITH PARTICULAR REFERENCE TO ITS EFFECT UPON BRANCH OR FEEDER LINES

M. F. Steinberger, Chairman, Sub-Committee; S. B. Cooper, H. C. Crowell, Olive W. Dennis, G. F. Hand, L. E. Little, R. J. Middleton, L. H. Powell, Mott Sawyer, J. E. Teal, B. Wheelwright.

At the Conventions of 1927 and 1928 this Committee presented reports which indicated the losses to the railways resultant from the growing use of automotive equipment operated over the highways. These losses have continued to grow. The Committee, therefore, feels that as that fact is now so generally recognized, it is unnecessary to quote statistics in support of this statement. In order that a realization may be had of probable future developments the Committee, therefore, desires to paint the picture and show what the developments with respect to the use of automotive highway vehicles have been during the past year, and what future developments may be.

New roads continue to be built, and with them continues an increase in the use of motor coaches and trucks. Consolidations of small independent motor lines into large, well financed, properly operated and maintained systems go on apace. The design of motor coaches and trucks continues to improve, thus increasing their adaptability to various transportation needs. This better design means also lower operating and maintenance costs, tending still further to broaden their sphere of usefulness.

The following figures are quoted from various sources to indicate the extent to which motor coaches and trucks are being used.

National Automobile Chamber of Commerce says as of January 1, 1928: "There are 29,505,475 motor vehicles in the world, of which 25,083,600 are private cars, 186,082 busses and 4,235,793 trucks. In the United States there are 20,156,115 private cars, 85,636 busses, 2,896,886 trucks, or a total of 23,138,637, which represents 78 per cent of the total number in the world." This is abounding proof of the motor mindedness of our people.

The same authority gives also the three following tables as of January 1, 1928:

Number of Motor Coaches Operated in the United States:

Motor Carriers	35,000	40.8 per cent
Electric Railways	8,492	9.9 per cent
Steam Railways	994	1.2 per cent
Total Common Carriers	44,486	51.9 per cent
Schools, Sight-seeing Companies, Hotels, etc.	41,150	48.1 per cent
Grand Total	85,636	100.0 per cent

Included in the 35,000 motor carrier operations above are 3200 independent interstate operations.

Number of Motor Trucks in Operation in the United States:

Privately Owned	2,375,447	82.0 per cent
Owned by Contract Carriers..	318,657	11.0 per cent
Owned by "For Hire" Operators, Including Common Carriers	202,782	7.0 per cent
Total	2,896,886	100.0 per cent

Passenger Cars Produced:

Year	*Number*	*Wholesale Value*
1899	4,192	$ 4,899,443.00
1910	181,000	213,000,000.00
1915	895,930	575,978,000.00
1920	1,905,560	1,809,170,963.00
1925	3,896,032	2,555,419,483.00
1927	3,086,018	2,269,056,222.00

1927 decrease due to lack in production of Ford cars.

These figures indicate the well-nigh amazing growth in the use of vehicles of the type shown, and the hold highway automotive vehicles have on the public.

In 1927 there were 287,928 miles of good roads in the States highway systems and 2,600,000 miles of county and local roads. A total of 575,000 miles were hard surfaced, and the total highway expenditures in 1927 were $1,123,607,055.00 as compared with $187,524,193.00 in 1913.

This is again indicative of the influence of the desire to use automotive highway vehicles. With all these things in mind it seems clearly demonstrated that the era of automotive transport is a permanent one. Its effect on branch or feeder lines of the railways has been demonstrated by the efforts of all the roads to reduce steam train service or eliminate them altogether or replace them by rail motor equipment. The reduction in or elimination of train service has, of course, been followed by reduced operating expenses, but at the same time has increased the revenues of the motor coach operators, strengthened them and enabled them to embark on still further competitive ventures.

For the first few years the railroads' problems were to meet the competition in their short haul territory Now, however, the field has broadened. Motor coaches are operated from Coast to Coast. One may travel between most large cities, whatever their distance apart, by motor coach. Sleeping car coaches are being used on the West Coast and in England.

One of the members of this Committee in a recent investigation developed that there are about 1400 bus arrivals and an equal number of departures at New York each day, which means over 50,000 people enter or leave New York each day by motor coach. A check made between St. Louis and Detroit showed night busses never carried less than 20 passengers per bus.

These incidents are cited simply to emphasize the point that there is a very large place in the transportation field for the automotive vehicle. What are the reasons for this:

With respect to the motor coach:

(1) Frequency of service.
(2) In many cases lower rates.
(3) Convenience, "store-door delivery" plan being applied to passenger travel.
(4) Scenery more pleasing.
(5) Less noise and dirt.
(6) See more of the cities and rural districts.
(7) The motor mindedness of the public.

With respect to motor truck use as against railways. (Report I. C. C. 18300.)

(a) Economy, including decreased crating costs, 45.0 per cent.
(b) Service and dependability, 42.0 per cent.
(c) Special equipment, 7.0 per cent.
(d) Advertising, 6.0 per cent.

Some of the general steps taken by the railways in meeting this highway competition have been:

(1) Opposition to granting of permits.
(2) Legislation providing regulation of rates, taxes, etc.
(3) Attempts to incorporate in rail service the features found attractive in highway motor service, or to offset them with other compensating attractions.
(4) Adoption of the highway vehicle by the railways as part of their own service.

Let us examine these in detail.

(1) Opposition Before Public Utilities Commissions to the Granting of Permits to Independent Operators

This was the first effort made and it has not been very successful. In some few cases competition has been prevented, but most permits have been granted. It is the history of transportation that efforts to restrict the growth of a new means of transportation have always failed, where there is a public demand and economic justification for the service; therefore, it does not seem expedient for the railways to carry this plan of opposition too far.

As a corollary to this statement, it may be said that one of the members of this Committee had an analysis made of the various Court or Public Service Commissions' decisions with respect to motor coach and motor truck operations in opposition to the railroads since 1922. Over a hundred decisions were so analyzed. The sense of these opinions in large majority was that the existing transportation companies should have an opportunity to supply service whether by road or by rail adequate to meet the demands of the situation. That is, the Courts and Commissions showed a willingness to co-operate with the railroads if the latter would give the service, but took the position that if the railroads failed to do so, then it was the duty of the Commissions to grant permits to independents.

A case of this kind occurred in West Virginia where the Baltimore and Ohio through a motor coach subsidiary applied for bus permits to operate over certain roads. These were denied and the permits granted an independent company. The railroad subsidiary took the cases to the Courts in West Virginia and secured rulings in both the Circuit and Supreme Courts that the railroad should have prior rights to bus permits over routes parallel or competitive with it. The independents then carried the case to the United States Supreme Court, and a decision from that Court ruled that no Federal question was involved and that the ruling of State Courts should apply. This favorable decision is of paramount importance to all the railroads.

(2) Regulations as to Rates, Schedules, Taxes, Safety Appliances, Financial Responsibility, Etc.

It is generally conceded that rates and schedules as well as the questions of safety appliances, financial responsibility, etc., should receive closer scrutiny by regulatory bodies and that similar regulations to those under which railroads operate should apply equally to motor coach and truck operations.

(a) RATES.—The Interstate Commerce Commission developed in its recent investigation that motor coach rates generally are higher for the short hauls than rail rates and lower in respect to long hauls. This would seem to indicate that the motor coach has a double appeal in that passengers are willing to pay more for the added frequency of service, convenience of central stations, etc., on short hauls and at the same time accept the inconveniences encountered in long hauls because of lower rates.

(b) TAXES.—The National Automobile Chamber of Commerce says that automotive vehicles paid in 1927 $760,373,652.81 in taxes of various kinds. This is a sizeable amount, but the fallacy of these figures is that no attempt is made to separate taxes paid by private automobiles and those by public carriers. Analyses have been made which indicate that in some states seat mile and ton mile taxes are paid in varying degree, in addition to gasoline, license, and other taxes.

There is undoubtedly a need for equalization of taxes, which need is influenced by the fact that the railroads pay a large share of highway taxes. It is the feeling of the Committee that the railroads should use all proper means to bring about an equitable tax scheme in so far as motor transport is concerned.

One important phase of this whole situation is the relation between this motor transport problem and grade crossing eliminations as well as demands for new passenger stations. The building of hard surface roads, which no one wants to see stopped, brings about the necessity for large expenditures for elimination of grade crossings. When faced by demands for new passenger station facilities or maintenance of unproductive train service, these two items constitute a heavy drain on railroad resources.

The public should be brought to a realization through proper Public Relations work of the direct connection between these items. If forced to pay large sums of money for road taxation, then necessarily elimination of grade crossings, new stations, etc., will come more slowly. A more equitable distribution of road taxes will better enable the railroads to meet other demands made upon them; and the railroads should through Public Relations Committees and their individual employees endeavor to bring these situations to the attention of the public so as to secure remedial action.

There have been large increases over the preceding years in the volume of road building material, automobiles, raw material for their construction, etc., handled by the railroads. For instance, it is stated that in 1927 3,267,388 carloads of autos, parts, gasoline, road building material, etc., were originated on the railroads as the direct result of the popularity of the automobile, and that the revenues therefrom should be considered as an offset to the unfair tax burdens.

The Committee feels that, while some consideration should be given this view, it should not be accepted as a reason for any discrimination in the taxes assessed in favor of automotive equipment. And, furthermore, the freight revenue derived from the shipment of one truck from the factory to destination will be offset by the revenue taken from the railroad by this truck in about two weeks' use.

(3) Attempts to Incorporate in Rail Service the Features Found Attractive in Highway Motor Service or to Offset Them with Other Compensating Attractions

(a) Frequency of Service and Convenience.—Most motor coach lines give a greater frequency of service and delivery of passengers closer to the centers of cities and towns than do the railroads. It is true that their average time between points is generally greater than that of railway trains, but that is offset by the fact that in most cases their frequency of service is such that the traveler can make better time between points by using the slower moving vehicle, which he can secure at more frequent times than he can if he waits the longer periods of time between trains even though the latter move faster on the trip.

It may be said then that the railroads should run more trains. It is generally not possible to do so, as the cost of the increased steam train service at about $1.00 per train mile Out of Pocket cost is too great to justify such operation when motor coaches costing $6,000 to $10,000 each and operating at a cost of 25 cents to 30 cents per mile give a similar service. The same argument applies to the operation of rail motor cars, which cost from 40 cents to 60 cents per mile to operate, and have a first cost of from $35,000 to $70,000 each. To give frequency of service approximating the bus service involves large capital expenditures for rail motor equipment. These are some of the reasons why service has not been improved, and why, when such improvements were made, desired results have generally not been attained. These figures are quoted in the manner shown because most roads in figuring justification of motor equipment use total costs including interest and depreciation against out-of-pocket steam train costs.

In order to meet motor coach competition certain railroads serving the same points have coordinated their services, each giving less service but together greater frequency.

(b) Lower Rates.—Experiments along this line with special excursions seem to show that this method alone does not bring back much of the lost business. In certain cases motor lines are able to operate successfully charging higher rates than the railroad. Generally where reduced rates have been put in effect, the railroads have done so in the place where such action has little result, i. e., in the shorter hauls.

(c) Adoption of Rail Motor Cars.—In certain cases steam trains have been replaced with rail motor equipment. The operation of rail motor cars has resulted in marked decreases in operating expenses, but in rare instances in any increase in revenues. Rail motor cars, which cost to operate from 40 cents to 65 cents per train mile, including interest and depreciation, and dependent upon physical characteristics of runs, certainly produce savings over steam trains whose out-of-pocket costs of operation average about $1.00 per train mile.

Inquiry through the Motor Transport Section of the American Railway Association has resulted in the practically unanimous reply that rail motor cars do not attract passengers back to the rails from highway motor coaches, but do materially reduce operating expenses, where rail service is necessary and can be furnished by rail motor cars.

Rail motor cars are failing to offset the motor coach because the people of this country have become motor minded. Most of them own automobiles. They have experienced tire troubles, have run out of gas, skidded on wet highways, been in traffic jams, etc., and have a kindred feeling for the motor coach company when those things happen on a motor coach. They understand them and are tolerant of them. They do not understand burst air hose, signal failures, delays due to freight wrecks ahead and the other things which happen on a railroad, and are critical of them. In brief, they feel at home on a motor coach and like to ride in one. They enjoy the scenery, can stop at any road crossing or farm gate, find the seats generally more comfortable than on average branch line trains, etc., and secure service approaching Pullman service at day coach rates or less.

(4) Adoption of the Motor Vehicle by the Railroads as a Part of Their Own Service

Of the four general methods of meeting the loss of revenue from highway competition, indifferent success has attended all except this last, in which the experiences of the New Haven, Boston and Maine, Great Northern, Southern Pacific, Spokane, Portland and Seattle, Baltimore and Ohio, Santa Fe, and many others indicate that such a plan is successful.

It may be of interest to indicate the use being made of highway motor equipment by the railways to as late a date as possible, that is, June, 1928.

Motor Coaches—	1927	1928
Roads operating motor coaches	52	64
Number motor coaches operated	800	1,047
Number motor coach routes operated	200	340
Average motor coach route mileage	8,000	14,805
Motor Trucks—		
Roads operating trucks, tractors and trailers	31	45
Number trucks, tractors and trailers operated	3,300	4,902
Number routes and terminals served	259	298

Since that time there have been decided increases in the railroad use of such equipment. This would seem to indicate a growing tendency on the part of our executives to utilize automotive equipment in the services for which it is fitted, and an inclination to the viewpoint that the function of the transportation companies is the furnishing of such transportation as is desired by the public rather than the furnishing of transportation by rail only.

Among the uses to which the railroads have put automotive highway vehicles are:

Motor Coaches

(1) In replacement of local train services.
(2) As adjuncts to local train service where local stops are handled by motor coaches and train stops eliminated, except at a few stations where passengers can transfer from motor coaches to trains.
(3) In feeder service.
(4) In tour service.
(5) As extensions of rail service; i. e., Baltimore and Ohio at New York.
(6) For long distance services paralleling rail lines, i. e., New Haven between New York and Boston.
(7) For handling employes, in replacement of workmen's trains.

Motor Trucks

(1) Inter-terminal transfers at various stations.
(2) Transfers between main and sub-stations.
(3) Replacement of local freight trains.
(4) Store door delivery.
(5) In stores departments.
(6) In connection with container services.
(7) Handling baggage and express in connection with motor coach service.
(8) Handling live stock, perishables, furniture, etc.

Because the major part of this report to this point has dealt with motor coaches should not be taken as an assumption that the motor truck competition is not a serious one. Trucks have absorbed large volumes of short haul freight and are also handling live stock, milk, furniture, fruits, vegetables, etc., for long distances. The same comments which apply to the motor coach apply equally to the motor truck.

As a result of its investigations this Committee expresses the following opinions for consideration by the executives of the railways with respect to automotive highway competition:

1. The automotive highway vehicle has a real place in the transportation field.

2. Continued efforts should be made to bring about equality in taxation and regulation, both with respect to intrastate and interstate operations.

3. The public desires "Good Service" whether given by bus, truck, rail motor car or steam train. By "Good Service" is meant giving the character of service desired by patrons in any of the above manners, and with due regard to the economics of the situation. Whether the service be great or small, it should be as nearly as possible what patrons desire, and of such nature as to meet the commendation and not the criticism of patrons.

4. The rail motor car should be adopted on all runs where economic justification can be found for its use. That is, where it is necessary to furnish a rail service and that service can be performed by the rail motor car.

5. The automotive highway vehicle should be used by the railroads for the transportation of passengers and freight wherever economic justification is found.

In this connection the following is quoted from a report of a meeting of the American Association of Passenger Traffic Managers in September, 1928:

> "The idea was advanced and enthusiastically reiterated by a number of speakers, that the only way for railways to meet the competition of the motor coach is for themselves to operate motor coaches. No serious objection to this proposal was advanced, although there was some difference as to the feasibility of each individual railway operating its own motor coach line. Several speakers while expressing themselves as strongly in favor of railroad operation of motor coaches, also held the opinion that for most sections of the country, coach lines owned by the railways jointly rather than individually offered the better prospect of success. Not one voice was raised in opposition to railroad operation of motor vehicles, although such operation, it was pointed out, could not hope to meet the situation in all territories and for all railways."

6. No mathematical formula can be worked out to fit all cases. Each situation should be studied and conclusions arrived at based on the individual study.

7. Generally speaking, if the study indicates doubt as to the possibility of securing a revenue of at least 25 cents per mile along any route, whether the vehicle be one to move on the rail or on the highway, then the service should be abandoned if possible.

If the possible indicated revenues are over 25 cents per mile, then if highway conditions are right serious consideration should be given the possibility of using highway motor service and eliminating rail trains.

If the revenues show indications of running above 45 cents per mile and it is not possible to use highway vehicles, then rail motor cars should be substituted for steam train service up to the ability of the rail car to meet the demands properly. The field of the rail car is widening with the construction of heavier cars, some of 800 HP. being already in service, although the costs of operating such heavier cars exceed the figures quoted above.

8. Motor trucks should be used in terminal transfer work, replacement of local freight trains and in all services where economic or traffic considerations make it desirable.

L.C.L. Containers

The subject assigined to this Committee also included the use of L.C.L. containers by the railroads. A brief history of the container idea is given in the following.

Since the inception of transportation by railway, efforts have been made to improve the methods of handling individual package, or what is known as less-car-load freight. Over half a century ago a British Army Officer evolved a plan for the movement of freight of this character by means of a container; the terminal movement being effected by means of horse drawn vehicles and the rail haul by the British railwagon. There was no general adoption of this plan, but the movement by horse drawn vehicle has remained a permanent adjunct to the operation of British railway systems, and what is known as the collection and delivery system, or generally spoken of in the United States as store door delivery, has been the permanent plan of the British and Canadian railways for a number of years.

There have been continued efforts in greater and lesser degree for the adoption of some similar plan in the United States, and the efforts of transportation men have been continuously directed to the problem of effectuating, first, an improved method of handling less-car-load freight by rail, and, second, of so coordinating that movement that a continuous movement of freight from door to door could be arranged for. There are numerous objections, largely from the policy standpoint, to the adoption of a store-door delivery plan in this country, and for that reason there has been no widespread development in this respect. However, the solution of the problem seems to be in the procurement of what is known as a container, which is simply a boxlike receptacle for the stowage of the small packages, and so constructed as to permit of handling from shipper's platform to road vehicles, either horse-drawn or motor truck, and from those vehicles to rail cars, and the reverse movement.

In the past ten years a number of schemes which would permit of this flexible handling of freight have been evolved, among them being:

(1) The Bonner Plan.
(2) The Kellett Plan.
(3) The tractor-trailer plan used by the Chicago, North Shore Electric Railway.
(4) The Perin-Walsh roll-off plan.
(5) The L.C.L. Corporation Plan in use on the New York Central and Lehigh Valley Railroads.
(6) The Church Freight Service Plan.
(7) The American Freight Service Incorporated Plan.

Because of certain defects all but the latter four plans have had little or no success, and of all of them the only ones which have had any reasonable success have been the Perin-Walsh scheme and the L.C.L. Corporation Plan. The Chicago and North Shore Plan has also been very effective in its particular field, but has not seemed applicable to general adoption.

Briefly, these plans are as follows:

The Bonner Plan

The Bonner Plan provided for the use of special equipment in the way of motor trucks, car floats and freight cars, all of which had to be specifically constructed for the purpose of using the container, which was also of special construction. The large capital expenditures required for this specialized equipment which could be used for no other purpose, removed it from general consideration.

The Kellett Plan

The Kellett Plan provides for the use of tractors and trailers, the trailer being fitted up with a closed body, the principle of the plan being that the trailer be run over a special loading platform from the cars and placed on flat cars equipped with special trucks and locking devices to keep the trailers in position on the cars. The entire container with its load generally being then moved to its destination and handled from the car to the shipper's door by means of tractors. This plan is similar to that used by the Chicago and North Shore Electric Railway and has seemed to fit the peculiar local situation involved in the handling of their freight between Chicago and Milwaukee.

The Perin-Walsh Plan

The Perin-Walsh Plan made a nearer approach to what is actually desired in the way of a container car operation, assuming, of course, that any container car operation is desirable. In this plan the container is a box-like receptacle set on castors which permit its operation over freight platforms, the handling being done by either industrial tractors or by manual labor. However, it is also necessary for this scheme to provide special motor trucks with chassis constructed for the handling of these containers as well as special devices to permit the movement from the freight platform to the railroad car, which is a flat car also specially equipped for use only in this container service. This operation has been successfully inaugurated by the Boston and Worcester Electric Railway, and to a limited degree by the Boston and Maine.

American Freight Service Plan

The plan provided for the use of containers 94 inches by 60 inches by 72⅝ inches, built of wood frames with steel sides, having two doors at each end and mounted on casters with a gage of 36 inches and wheelbase of 35 inches. These containers were to be trucked to and from freight stations on special motor trucks and wheeled across platforms, where they were to be loaded in box cars.

Church Freight Service Plan

This is a plan similar to the above, except that the size of containers is 72 inches by 72 inches by 36 inches. They are to be handled in the same manner as above.

L.C.L. Corporation Plan

This scheme provides large steel containers, which are trucked to and from freight stations, where they are lifted by cranes from the trucks and placed six to a car in low side gondola cars about 46 feet long. One road uses a similar container in the same way, placing on flat cars. Of these plans the latter has had the greatest measure of success.

In its inception it was thought that the major use to be found for containers would be in the movement of L.C.L. freight from door of consignor to door of consignee, truck being used at either end and the railroad as the transportation medium between cities. It has since developed that the volume of freight susceptible of such handling is so small that it is only through the use of containers by some freight-consolidation medium that a real use can be found for them.

Among the advantages claimed for containers are:

1. Reduction in freight station expenses.
2. Reduction in general office expenses.
3. Reduction in loss and damage claims.
4. Reduction in switching costs.
5. Elimination of thefts.
6. Ability to handle increased business with no increase in station facilities.
7. Reduction in car repairs.
8. Increased utilization of equipment.
9. Reduction in expense of train operation.
10. Increased car load.
11. Reduced crating expense to shippers.
12. Quicker service.

Among the claimed disadvantages are:

1. Necessity for use of special equipment, cranes, etc.
2. Cross haul of empty cars.
3. Inability to handle at shippers' warehouses account of lack of cranes.
4. Possibility of disturbing existing rate structure.
5. Car and container accounting.
6. Charge for use of containers.
7. Loss of freight revenue due reduction in use of crates.
8. Duplication of less than car load service, because all freight cannot move in containers.
9. Possibility of reduced gross revenues because of lowered rates, if not offset by increased business.

At the present time containers are used on the following roads:

New York Central.
Pennsylvania.
Lehigh Valley.
Boston and Worcester.
Chicago and North Shore.
Bush Terminals at New York.
All railroads at Cincinnati and by some business concerns for terminal handling of their freight.

This Committee, as a whole, has not studied these items in detail and present them only for guidance of members. It is the feeling of the Committee that very careful consideration be given each of these items; however, in the study of container schemes, with a view to actually determining the economic possibilities involved.

This Committee was also charged with the study of effect of airplanes on the railways. Some information has been gathered on this subject which shows a decided increase in the use of airplanes by the public, and some roads have already recognized the desirability of doing what most failed to do with the bus; namely, co-ordinate the two services, rail and air. The Committee, therefore, at this time wishes only to report progress with respect to investigation into airplane activities.

Appendix G

(9) STUDY ECONOMIES RESULTING FROM USE OF RADIO TELEPHONES FOR LONG FREIGHT TRAINS AND FOR YARD WORK

G. D. Brooke, Chairman, Sub-Committee; B. T. Anderson, S. B. Cooper, J. M. Farrin, E. E. Kimball, H. T. Porter, L. S. Rose, B. J. Schwendt, J. E. Teal, B. Wheelwright.

The Sub-Committee reports progress.

REPORT OF COMMITTEE VIII—MASONRY

C. P. Richardson, *Chairman;*
*Job Tuthill, *Vice-Chairman;*
J. T. Andrews,
C. N. Bainbridge,
F. E. Bates,
J. A. Bohland,
G. E. Boyd,
M. F. Clements,
T. L. Condron,
W. T. Davis,
E. Duncan,
T. L. D. Hadwen,
A. D. Harvey,
W. K. Hatt,
M. Hirschthal,
Hans Ibsen,
A. C. Irwin,
G. M. Johnson,
A. R. Ketterson,
J. A. Lahmer,
A. N. Laird,
J. F. Leonard,
J. A. Parant,
W. L. Roller,
D. B. Rush,
F. E. Schall,
L. W. Skov,
A. W. Smith,
S. E. Smith,
I. F. Stern,
E. E. Stetson,
R. A. Van Ness,
C. C. Westfall,
C. C. Williams,
P. H. Winchester,
J. J. Yates,

Committee.

* Died, December 28, 1928.

To the American Railway Engineering Association:

Your Committee on Masonry respectfully presents herewith its report on:

(2) Principles of design of concrete, plain and reinforced, for use in railroad structures.

(3) Study and report upon progress in the science of concrete manufacture.

(6) Study and report upon general practices for waterproofing railway structures.

(7) Outline of work for the ensuing year.

Action Recommended

(2) Principles of design of concrete, plain and reinforced, for use in railroad structures (Appendix A).

(a) That Section I on "Design of Reinforced Concrete Columns" be adopted and printed in the Manual of Recommended Practice of this Association.

(b) That the subject-matter in Section II, entitled "Tentative Standard Specification for Reinforced Concrete Culvert Pipe, as submitted in the "Second Report of the Joint Concrete Culvert Pipe Committee" be adopted and printed in the Manual of Recommended Practice.

(c) That Section III on Reinforced Concrete Flat Slabs be accepted as information.

(3) Report upon progress in the Science of Concrete Manufacture (Appendix B).

That the definitions of "Special Cements and Admixtures" be adopted and printed in the Manual of Recommended Practice of the Association.

That the report on Moisture and Bulking of Aggregate be received as information.

(6) Study and report upon General Practices for Waterproofing Railway Structures (Appendix C).

Progress report to be received as information.

Bulletin 313, January, 1929.

Recommendations for Future Work

1. Continue study of subject-matter in the Manual with a view of recommending changes.

2. Continue the study of principles of design for plain and reinforced concrete for use in railway buildings, bridges and culverts, collaborating with Committee I—Roadway, VI—Buildings, XV—Iron and Steel Structures, and XVIII—Electricity.

3. Continue the study and report upon progress in the science and art of concrete manufacture.

4. Maintain contact with Joint Committee on Standard Specifications for Concrete and Reinforced Concrete and report to the Association.

5. Continue the study of specifications for foundations, including excavation, cofferdams, piling, etc.

6. Continue the study and report upon general practices for waterproofing railway structures, collaborating with Committee VI—Buildings and Committee XV—Iron and Steel Structures.

7. Outline of work for ensuing year.

Respectfully submitted,

The Committee on Masonry,

C. P. Richardson, *Chairman.*

Job Tuthill

The Committee was greatly shocked to learn of the sudden death of Mr. Job Tuthill on the morning of December 28.

The Committee has adopted the following resolution:

Whereas, Death has removed from us Mr. Job Tuthill, and

Whereas, He has been for many years a loyal and efficient member and Vice-Chairman of the Masonry Committee of this Association, and

Whereas, In his earnest, conscientious and thorough manner, he has done much to advance the art of railway engineering, and

Whereas, To know him was to respect him as an outstanding Engineer and to cherish him as a personal friend, therefore

Be It Resolved, That the Masonry Committee of the American Railway Engineering Association expresses its deep sorrow and the keen sense of its great loss, and

Be It Further Resolved, That a copy of this resolution be sent to his widow, and that a further copy be placed in the records of this Committee and the American Railway Engineering Association.

Mr. Tuthill has been continuously active on the Masonry Committee for the past twenty-two years, acting as Vice-Chairman for the past eight years. During the past year he contributed much to the work of the Committee. His death was a great shock to his friends and associates. Mr. Tuthill died of pneumonia following a very short illness.

Appendix A

(2) PRINCIPLES OF DESIGN OF CONCRETE, PLAIN AND REINFORCED

M. Hirschthal, Chairman, Sub-Committee; Job Tuthill, C. N. Bainbridge, F. E. Bates, T. L. Condron, A. C. Irwin, A. R. Ketterson, A. N. Laird, J. F. Leonard, L. W. Skov, A. W. Smith, I. F. Stern, C. C. Westfall.

(I) COLUMNS

121. **Limiting Dimensions.**—Unless designed as long columns, under the provisions of Section 126, reinforced concrete columns shall not be longer than twelve times the least lateral dimension. Continuous columns shall have a minimum diameter or thickness of 12 in. Non-continuous columns shall have a minimum diameter or thickness of 6 in.

122. **Unsupported Length of Columns.**—The unsupported length of reinforced concrete columns shall be taken as:

(a) In flat-slab construction the clear distance between the floor and under side of the column capital.

(b) In beam-and-slab construction, the clear distance between the floor and the under side of the shallowest beam framing into the column at the next higher floor level.

(c) In floor construction with beams in one direction only, the clear distance between floor slabs.

(d) In columns supported laterally by struts or beams only, the clear distance between consecutive pairs (or groups) of struts or beams, provided that to be considered an adequate support two such struts or beams shall meet the column at approximately the same level and the angle between the two planes formed by the axis of the column and the axis of each strut respectively is not less than 75 deg. nor more than 105 deg.

(e) When reinforced concrete brackets are used at the junction of beams or struts with columns the clear distance between supports may be considered as reduced by the depth of the bracket, provided the width of the bracket is at least equal to that of the beam and not less than one-half the column.

123. **Design of Spiral Columns.**

(a) The permissible axial load on columns reinforced with longitudinal bars and closely spaced spirals enclosing a circular core shall not be greater than that determined by formula 36.

$$P = A_c\,[1 + (n - 1)\,p]\,f_c \quad \text{.....} \quad (36)$$

in which A_c is the area within the outer circumference of the spiral hooping, and the values of f_c, as found by the formula,

$$f_c = (.25 + 12\,p')\,f'_c \quad \text{.....} \quad (37)$$

in which, f'_c = the ultimate compressive strength of the concrete in 28 days, and p' is the ratio of the volume of spiral reinforcement to the volume of the column core.

(b) The longitudinal reinforcement shall consist of at least six bars of minimum diameter of ½ inch, and of an effective cross-sectional area not less than 0.01, nor more than 0.06 of that of the core. The number of longitudinal bars concentrated in the ring at the periphery of the core shall be governed by the spacing requirements of Section 53. When the ratio of reinforcement in a spirally reinforced column is such as to require two rings of bars, special drawings illustrating the proper distribution of steel shall be shown on the detail plans. Splices in longitudinal reinforcement shall occur only where the column is laterally supported and shall provide sufficient lap to transmit the stress by bond, but not less than 24-bar diameter for deformed bars, and 30 diameters for plan bars.

(c) The ratio of the spiral reinforcement to the core shall be not less than .005 nor less than one-fourth the volume of the longitudinal reinforcement. Spiral reinforcement shall conform to the provisions of Section 14 of these specifications. The pitch of the spirals shall not be greater than one-sixth of the diameter of the core and in no case more than 3 in.

(d) Reinforcement shall be protected everywhere by a covering of concrete cast monolithic with the core and which shall have a minimum thickness of 1½ in.

124. **Design of Columns with Lateral Ties.**

(a) The permissible axial load on columns reinforced with longitudinal bars and separate lateral ties shall be not greater than that determined by formula 38:

$$P = A'_c\,[1 + (n - l)\,p]\,.25\,f'_c \quad \text{.............................} \quad (38)$$

where A'_c = the area enclosed within the lateral ties.

(b) The ratio of longitudinal reinforcement to the core area shall be not less than 0.01 nor shall the ratio considered in the calculations be more than 0.03 of the core area of the column, nor more than .02 of the gross area. The longitudinal reinforcement shall consist of not less than four bars of minimum diameter of ⅝ in., placed with clear distance from the face of the column not less than 1½ in., nor more than 3 in. Splices in longitudinal reinforcement shall occur only where the column is laterally supported and shall provide sufficient lap to transmit the stress by bond, but not less than 24-bar diameters for deformed bars, and 30 diameters for plain bars.

(c) Lateral ties shall be at least ¼ in. in diameter spaced not more than 8 in. apart nor more than the least dimension of the column. In columns of rectangular section, cross ties shall be arranged to afford support to the vertical bars at intervals not greater than the shorter side of the section, but such interval need not be less than 12 in. in any case.

125. **Bending in Columns.**

(a) Stresses due to the bending moments in interior and exterior columns shall be determined on the basis of loading conditions and end restraint, and the columns designed for the combined bending and axial load stresses.

(b) In flat-slab construction, the least dimension of the column shall be not less than one-fifteenth of the average center to center span, nor less than 16 in. except for roof columns which shall be not less than 12 inches in least dimension. For known eccentric loads or unequal spacing of columns, computations of moments shall be made accordingly. Wall columns in flat-slab construction shall be designed to resist a bending moment of $Wl/35$, where W is the total load, dead and live, and l equals length of span. Any counter moment due to the weight of the structure that projects beyond the column center line may be deducted from the moment computed as just described. Resistance to the bending moments shall be divided between the columns immediately above and below in direct proportion to the values of their ratios of I/h.

(c) Recognized methods shall be followed in calculating the stresses due to combined axial load and bending. The column section shall be not less than that required where axial load alone is considered. The limiting combined unit stresses shall be as follows:

(1) Columns with spiral reinforcement,

$$f_c = (.25 + 12\,p')\,f'_c + 0.15\,f_c' \text{ but not more than } .5\,f'_c.$$

(2) Columns with lateral ties 0.3 f'_c. The total amount of reinforcement considered in the computations shall be not more than 4 per cent of the core area or more than 3 per cent of the gross area of the column.

(3) Tension in longitudinal reinforcement due to bending on the column shall not exceed 16,000 lb. per sq. in.

(d) Columns subject to both axial load and bending stresses due to wind loads may be proportioned for unit stresses not more than 50 per cent larger than those allowed for direct axial load; but the section shall be not less than that required for axial load and bending.

126. **Long Columns.**

(a) The permissible working load on the core in axially loaded spiral or tied columns which have a length greater than 12 times the least dimensions of the column (12D) shall be not greater than that determined by formula 39.

$$\frac{P'}{P} = 1.33 - \frac{h}{36D} \qquad (39)$$

(II) CULVERT PIPE

The second report of the Joint Concrete Culvert Pipe Committee, composed of representatives of this Association and other organizations, submitting Tentative Standard Specifications for Reinforced Concrete Culvert Pipe, is presented herewith with the recommendation that the specifications be adopted and printed in the Manual.

The Specifications are termed "tentative," to comply with the requirements and customs of several of the other associated organizations. They are the result of long study by the Joint Concrete Culvert Pipe Committee and are based on many tests of full size pipe procured from different manufacturers, made as nearly as possible in accordance with the proposed design. These tests showed that pipe complying with the strengths specified could be made with less reinforcement than was required by the unit stresses: 16,000 lb. per sq. in. for steel, of the 1926 specifications. The unit stresses were, therefore, raised to those of the present specification, and are based upon the results of the tests of pipe made under the proposed specifications.

Design tables for two classes of pipe are given; pipe for any conditions of loading and material can be designed under the proposed method.

The Committee, therefore, recommend the adoption of the Specifications and that they be printed in the Manual.

SECOND REPORT

of the

Joint Concrete Culvert Pipe Committee

Submitting

TENTATIVE STANDARD SPECIFICATIONS FOR REINFORCED CONCRETE CULVERT PIPE

Constituent Organizations

American Society for Testing Materials
Bureau of Public Roads, U. S. Department of Agriculture
American Society of Civil Engineers
American Association of State Highway Officials
American Railway Engineering Association
American Concrete Institute
American Concrete Pipe Association

Submitted to Constituent Organizations

1928

American Society for Testing Materials

Dean Anson Marston (Chairman), Iowa State College, Ames, Iowa.

A. E. Phillips, Consulting Engineer, 2400 Wyoming Avenue N. W., Washington, D. C.

Bureau of Public Roads

T. H. MacDonald, Chief, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

A. T. Goldbeck, Director, Bureau of Engineering, National Crushed Stone Association, 751 Earle Building, Washington, D. C. (Formerly Chief of Tests, Bureau of Public Roads, Washington, D. C. Resigned, 1926.)

E. F. Kelley, Chief, Division of Tests, Bureau of Public Roads, Department of Agriculture, Washington, D. C. (Succeeded A. T. Goldbeck, 1926.)

American Society of Civil Engineers

George H. Tinker, Bridge Engineer, N. Y. C. & St. L. Ry., 926 Terminal Tower Bldg., Cleveland, Ohio.

T. L. D. Hadwen, Asst. Engr., C. M. St. P. & P. Ry., 898 Union Station, Chicago, Ill.

American Association of State Highway Officials

T. R. Agg, Professor of Highway Engineering, Iowa State College, Ames, Iowa.

J. N. Mackall, Chairman, Maryland State Roads Commission, Garrett Building, Baltimore, Md.

American Railway Engineering Association

Job Tuthill, Asst. Chief Engineer, Pere Marquette Railway, Fort St. Depot, Detroit, Mich.

A. F. Robinson, Bridge Engineer, A., T. & S. F. Ry., Railway Exchange Building, Chicago, Ill. (Resigned, 1925.)

G. A. Haggander, Bridge Engineer, C., B. & Q. R. R., 547 W. Jackson Blvd., Chicago, Ill. (Succeeded A. F. Robinson, 1925.)

American Concrete Institute

B. S. Pease, Manager, Reinforcing Department, American Steel & Wire Co., 208 S. LaSalle St., Chicago, Ill.

A. B. Cohen, Consulting Engineer, 1 Madison Ave., New York, N. Y. (Resigned, 1926.)

F. F. Longley, Lock Joint Pipe Co., Ampere, N. J. (Succeeded A. B. Cohen, 1926.)

American Concrete Pipe Association

Paul Kircher, Vice President, Canadian Concrete Products Co., Ltd., 312 Transportation Bldg., Montreal, Quebec, Canada.

W. H. Robertson, Massey Concrete Products Corp., Hudson Terminal Bldg., 50 Church St., New York, N. Y. (Succeeded the late Paul Kircher, 1927.)

C. F. Buente, Secretary, Concrete Products Company of America, Diamond Bank Building, Pittsburgh, Pa.

M. W. Loving, Secretary
33 West Grand Ave.
Chicago, Ill.

SECOND REPORT
OF THE
JOINT CONCRETE CULVERT PIPE COMMITTEE

The Joint Concrete Culvert Pipe Committee was organized in 1919 to prepare standard ecifications for reinforced concrete pipe to be used for railway and highway culverts. The mmittee has held one or more meetings each year since its organization and in February, 26, it presented to the constituent organizations a report embodying recommended tentative andard specifications for reinforced concrete culvert pipe. That report was very widely distbuted; more than 5,000 copies being furnished to public officials and manufacturers and ers of pipe in the United States and Canada.

At the outset the committee found that there was little known with reference to the actual ads to which culverts are subjected. An investigation of this subject had been inaugurated Iowa State College under the direction of Dean Anson Marston. The committee encoured the vigorous prosecution of that work so that the results could be used in connection th the development of the specifications for culvert pipe. One meeting of the committee as held at Ames at which time the research under way was reviewed and the whole problem loads was given extended consideration. At later times, two progress reports on the Ames vestigation were submitted to the committee. The data included were of great value in conction with the determination of the loads for which culvert pipe should be designed.

A considerable amount of data from tests of pipe and from experience in the use of pipe ere furnished by members of the committee and by manufacturers of pipe and engineers ho had installed pipe or observed its behavior in embankments. All of this material was nsidered by the committee when the first tentative specifications were being prepared.

After the 1926 specifications were distributed the committee accumulated evidence indicatg that pipe could be produced to meet the strength requirements with less circumferential inforcement than was prescribed by the specifications. Accordingly the committee arranged r a series of tests to be made under the direction of W. J. Schlick, Drainage Engineer, Iowa ngineering Experiment Station, for the purpose of securing information with reference to this bject. Pipe with various amounts of circumferential reinforcement and made of concrete various strengths, were made and tested under the direction of Mr. Schlick in 8 pipe plants the United States. There were 167 standard sections ranging from 12 to 60 inches in ameter. These tests showed that pipe of the specified strengths could be made with less cumferential reinforcement than was required by the 1926 specifications.

Meanwhile there had developed a demand for the inclusion of an absorption specification d in 1927 the Committee arranged for Mr. Schlick to test for absorption specimens of conete pipe furnished by manufacturers in various parts of the United States.

Copies of the reports on the two series of tests may be obtained from the Secretary of the merican Concrete Pipe Association, 33 West Grand Avenue, Chicago, Illinois.

The information secured from the tests and the additional facts that have been developed th reference to loads subsequent to the previous reports were the basis of the accompanying vision of the 1926 specifications. The principal revisions are in the amount of circumrential reinforcement, the load requirement for Extra Strength Pipe and the inclusion of absorption test.

The moment formula given in the section on design is essentially the one developed years o for an elastic ring under opposed external forces. A discussion of this theory was prented by Prof. A. N. Talbot of the University of Illinois in Bul. 22 of the Illinois Engineering xperiment Station entitled, "Tests of Cast Iron and Reinforced Concrete Culvert Pipe," which now out of print.

Early in its deliberations the committee decided that, while culvert pipe may be used under any conditions of loading, it is feasible to meet all ordinary commercial needs with two stock, standard, classes of pipe. The formulas for design provide a means of designing pipe to eet any special condition of loading for which standard pipe are not adapted.

The assumptions as to load for the two classes of pipe have been correlated with the rength test requirements and were adopted after considering the results of strength tests of pe and measurements of actual loads on pipe.

The work of the committee was greatly facilitated by the cordial cooperation of manufacrers of culvert pipe. The industry assisted the committee in many ways and several manucturers furnished pipe for testing and facilities at their plants for making the required tests.

It is the recommendation of this committee that the specifications submitted herewith be lopted by each constituent organization as tentative standard specifications for reinforced ncrete culvert pipe, superseding those reported in February, 1926.

TENTATIVE STANDARD SPECIFICATIONS
FOR
REINFORCED CONCRETE CULVERT PIPE

I. GENERAL

1. These specifications apply to reinforced concrete pipe intended to be used for the construction of culverts. **Scope**

2. Pipe, under these specifications, shall be of two classes known respectively as *Standard Reinforced Concrete Culvert Pipe* and *Extra Strength Reinforced Concrete Culvert Pipe.* **Classes**

3. The acceptability of pipe shall be determined by the results of the strength and absorption tests hereinafter specified, if and when required, and by inspection to determine whether the pipe comply with the specifications as to design, and freedom from defects. **Basis of Acceptance**

II. MATERIALS

4. The reinforced concrete shall consist of portland cement, mineral aggregate and water in which steel has been embedded in such a manner that the steel and the concrete act together in resisting forces. **Reinforced Concrete**

5. Portland cement shall meet the requirements of the current Standard Specifications and Tests for Portland Cement of the American Society for Testing Materials. **Cement**

6. Reinforcement may consist of wire which meets the requirements of the current Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement of the American Society for Testing Materials, or of bars which meet the requirements of the current Standard Specifications for Billet-Steel Concrete Reinforcement Bars of the American Society for Testing Materials. **Steel**

7. *(a)* Fine aggregate shall consist of sand, stone screenings, or other inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated grains and free from injurious amounts of dust, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances. Fine aggregate shall be well graded and shall pass a ¼-inch screen. **Fine Aggregate**

(b) Coarse aggregate shall consist of crushed stone, gravel, slag, or other approved inert materials with similar characteristics, or combinations thereof, having clean, hard, strong, durable, uncoated particles, free from injurious amounts of soft, friable, thin, elongated or laminated pieces, alkali, organic or other deleterious matter. **Coarse Aggregate**

8. The aggregates shall be so graded and proportioned and thoroughly mixed with such a proportion of cement and water as will produce a homogeneous concrete mixture of such quality that the concrete will meet the test and design requirements herein specified. **Mixture**

III. DESIGN

9. The pipe shall be designed in accordance with the following assumptions:

(a) That the design load is equivalent to a vertical load uniformly distributed over the internal horizontal projection of the pipe, that the pipe is likewise uniformly supported and that no allowance is made for side pressure.

(b) The uniform load for the Standard Reinforced Concrete Culvert Pipe shall be 2000 pounds and for the Extra Strength Reinforced Concrete Culvert Pipe 4000 pounds per square foot respectively.

(c) The working stress per square inch in compression for the concrete shall not exceed three-eighths of the strength of concrete upon which the design is based.

(d) The ratio (n) of the modulus of elasticity of steel to that of concrete shall be 12 for concrete having an ultimate compressive strength at 28 days of 2,750 lb. per sq. in. and 9 for concrete having an ultimate compressive strength of 4,000 lb. per sq. in. or greater. Intermediate values of "n" shall be proportional to the strength of concrete assumed in the design. **Methods of Design**

(e) The working stress for cold-drawn steel wire shall not exceed 27,500 lb. per sq. in. For billet-steel, intermediate and hard grades, the working stress shall not exceed 20,000 lb. per sq. in.; and for billet-steel, structural grade, the working stress shall not exceed 18,000 lb. per sq. in.

(f) The distance from the center of the reinforcement to the nearest or tension surface of the concrete shall not be less than ¾ inch for pipe 12 inches or less in diameter, or less than one inch for pipe more than 12 inches in diameter.

(g) The distance from the center of the tension reinforcement to the compression surface of the concrete and the area of the reinforcement shall not be less than that required by the formula—

$$\frac{wd}{16} \times \frac{d+t}{12} = jAtf_s$$

in which w = uniform vertical load in pounds per square foot top and bottom of pipe
d = internal diameter of pipe in inches
t = distance from the center of the tension reinforcement to the compression surface of the concrete in inches
A = sectional area of tension reinforcement in square inches per lineal foot of the pipe
f_s = tensile stress in the reinforcement in pounds per square inch
j = ratio of the lever arm of the reinforcement to "t" as determined by the usual formulas

10. The shell thickness and the amount of circumferential reinforcement shall not be less than that given in the design tables for the classes and sizes of pipe and the strength of concrete therein specified. **Minimum Designs**

11. Manufacturers may submit to the consumer or purchaser, for approval, designs based on strengths of concrete other than those given in the design tables. Such alternate designs shall comply with the design requirements given in Section III of these specifications. In no alternative design, however, shall the shell thicknesses be less than those given in Table II, nor shall the strength of concrete be less than that given in Table I. **Alternative Designs**

12. Pipe of the internal diameters listed in the design tables shall be considered standard sizes for culvert construction. In elliptical pipe, the inside diameter at the minor axis shall be equal to the diameter of the corresponding size of circular pipe. **Standard Sizes**

13. The ends of the pipe shall be of such design that the pipe when laid shall make a continuous conduit with a smooth and uniform interior surface. **Joints**

14. When a single line of circular reinforcement is used in circular pipe, it shall be placed at the center of the pipe shell. When two lines of reinforcement are used in circular pipe, one shall be placed near the inner and one near the outer surface of the pipe. The single line of elliptical reinforcement used in circular pipe, or the single line of circular reinforcement in elliptical pipe shall be placed near the inner surface at the "top" and "bottom" of the pipe and near the outer surface at the sides (see Paragraph 20 (d)). **Placing Reinforcement**

15. Each line of circumferential reinforcement shall be assembled into a cage and have sufficient longitudinal bars or members, extending through the barrel of the pipe, to afford rigidity and maintain the reinforcement in exact shape and correct position within the form. **Longitudinals**

16. The reinforcement shall be lapped not less than 30 diameters, or if welded, the joints shall develop the full strength of the reinforcement. The spacing center to center of adjacent rings of circumferential reinforcement in a cage shall not exceed 4 inches up to and including pipe 48 inches in diameter, nor exceed the shell thickness for larger pipe and shall in no case exceed 6 inches. **Laps and Welds**

17. The bell shall have a circumferential reinforcement equal in unit area to that of a single line within the barrel of the pipe. **Bell Reinforcement**

IV. WORKMANSHIP AND FINISH

18. Pipe shall be substantially free from fractures, large or deep cracks and surface roughness. The planes of the ends of the pipe shall be perpendicular to their longitudinal axes. **Finish**

19. *(a)* Variations of the internal diameter shall not exceed 1½ per cent nor shall the shell thickness be less than that intended in the design by more than 5 per cent at any point. **Variations in Dimensions**

(b) Variation in the position of the reinforcement cages shall not exceed ¼ inch from the position provided in the design, nor shall the cover on the reinforcement be less than ¾ inch at any point.

V. MARKING

20. The following shall be clearly stenciled on the pipe:

(a) The pipe class {by an "S" for Standard Pipe / and an "X" for Extra Strength Pipe — Markings

(b) The date of manufacture

(c) The name or trade-mark of manufacturer

(d) Elliptical pipe with circular reinforcing and circular pipe with elliptical reinforcing shall have the words "Top or Bottom" clearly stenciled on the inside of the pipe at the correct place to indicate the proper position when laid.

VI. PHYSICAL TESTS

21. Pipe may be tested for strength by either the three-edge or sand bearing method: — Strength Tests

(a) When the three-edge bearing is used, the lower bearing for the pipe shall consist of two wooden strips with vertical sides having their interior top corners rounded to a radius of approximately ½ inch. The strips shall be straight and shall be securely fastened to a rigid block with the interior vertical sides spaced a distance apart not less than ½ inch nor more than 1 inch for each foot of diameter pipe. The upper bearing shall be a rigid wooden block, straight and true from end to end. The upper and lower bearings shall extend the full length of pipe exclusive of bell. The pipe shall be placed symmetrically between the two bearings as illustrated in Figs. 3 and 4. In testing pipe which is "out of line" the lines of the bearings chosen shall be from those which appear to give the most favorable conditions for fair test. — Three-Edge Bearing Test

(b) When sand bearings are used (see Figs. 2 and 5), the ends of each specimen of pipe shall be accurately marked prior to the test in quarters of the circumference. Specimens shall be carefully bedded, above and below, in sand, for one-fourth the circumference of the pipe measured on the middle line of the barrel. The depth of bedding above and below the pipe at the thinnest points shall be one-half the radius of the middle line of the barrel.

The sand used shall be clean and moist, and shall be such as will pass a 4760-micron sieve (U. S. Standard No. 4). The sand in the lower bearing shall be loose when the pipe is placed.

The top bearing frame shall not be allowed to come in contact with the pipe nor with the top bearing plate. The upper surface of the sand in the top bearing shall be stuck level with a straight edge, and shall be covered with a rigid top bearing plate, with lower surface a true plane, made of heavy timbers or other rigid material, capable of distributing the test load uniformly without appreciable bending. The test load shall be applied at the exact center of this top bearing plate, or in such manner as to produce uniform deflection throughout the full length of the pipe. For this purpose a spherical bearing is preferred. — Sand Bearing Test but two rollers at right angles may be used. The test may be made without the use of a testing machine, by piling weights directly on a platform resting on the top bearing plate, provided, however, that the weights shall be piled symmetrically about a vertical line through the center of the pipe, and that the platform shall not be allowed to touch the top bearing frame.

The frames of the top and bottom bearings shall be made of timbers so heavy as to avoid appreciable bending by the side pressure of sand. The interior surfaces of the frames shall be dressed. No frame shall come in contact with the pipe during the test. A strip of cloth may, if desired, be attached to the inside of the upper frame on each side, along the lower edge, to prevent the escape of sand between the frame and the pipe.

(c) It is desirable that a machine shall be used which gives a uniform deflection throughout the full length of the pipe. Any mechanical or hand power device may be used in which the head that applies the load moves at a speed of not more than 0.05 inches per minute while making the test. The testing machine shall be substantial and rigid throughout, so that the distribution of the load will not be affected appreciably by the deformation or yielding of any part. The load shall be applied continuously until the ultimate strength of the pipe is reached. **Application of Load (Testing machine)**

22. The ultimate load, as determined by one of the methods described in Paragraph 21, shall not be less than the ultimate load specified in Table V for the size and class of pipe that is being tested. When the test load reaches the cracking load specified in Table V for the size and class of pipe that is being tested, there shall be in the barrel of the pipe no crack having a surface width of 1/100 inch* or more, for a length of one foot or more. The ultimate load is reached when the pipe will sustain no greater load. **Strength Requirements**

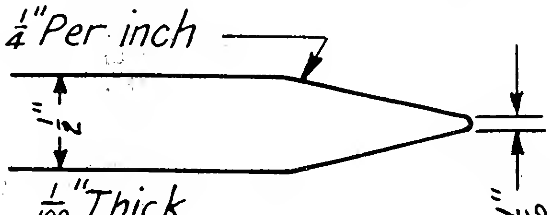


Fig. 1

*It is recommended that the width of the crack be measured by means of a gage made from a leaf 1/100-inch thick from a set of standard machinists' gages, ground to a point 1/16-inch wide, with corners rounded, and with a taper of ¼-inch per inch, as illustrated by Fig. 1. The crack shall be considered to be 1/100-inch wide when the point of the gage will just enter it at close intervals.

23. Elliptical pipe shall meet the test requirements for circular pipe having the same horizontal internal diameter. **Elliptical Pipe**

24. Preliminary to placing an order, a consumer of pipe whose needs require shipments at intervals over extended periods of time shall be entitled to test not more than ten pieces of pipe covering the size in which he is interested. The test specimens shall be selected in approximately equal numbers from the larger and smaller sizes of pipe. The acceptability of the larger sizes of pipe shall not be based on the results of tests in smaller sizes. After these preliminary tests, a consumer shall be entitled to additional tests in such numbers and at such times as he may deem necessary, provided that the total number of pipe tested shall not exceed two per cent (2%) of the total deliveries. Preliminary Tests and Tests for Extended Deliveries

25. A purchaser who places occasional orders shall be entitled to test a number of pipe equal to two per cent (2%) of an order but not to exceed five pieces of any one size; otherwise the number of pipe desired for testing shall be included in the order. Tests for Occasional Orders

26. All pipe for testing purposes shall be selected at random by the consumer or purchaser from the stock of the manufacturer and shall be pipe which would not otherwise be rejected under these specifications. The pipe shall be free from visible moisture when tested. Selecting Test Specimens

They shall not have been exposed to a temperature below 40 degrees (F.) for the 24 hours immediately preceding the test.

27. By agreement between the consumer and the manufacturer the continued acceptability of the pipe, after the preliminary pipe tests have been made, may be determined by tests of the quality of the concrete as placed in the pipe and examination of the quality, amount and the accuracy of placement of the reinforcement. The quality of the concrete shall be determined on 6 by 12-in. test cylinders taken from the concrete used in making the pipe and manufactured and cured under identical conditions with the pipe. When tested in accordance with the current standard methods prescribed by the American Society for Testing Materials, these cylinders shall have a strength not less than that assumed in the design of the pipe. Cylinder Tests and Reinforcement Examinations

28. Pipe shall be acceptable under the strength tests when all test specimens meet the test requirements. Should less than three of the ten preliminary test specimens or any one of the additional test specimens provided for in Paragraph 24, or any one specimen provided for in Paragraph 25 fail to meet the test requirements, then the manufacturer will be allowed a retest on two like specimens for each specimen that failed, and the pipe shall be acceptable only when all of these retest specimens meet the test requirements. No further retests shall be permitted. Retests

29. Absorption tests shall be made by the following method:

(a) The number of absorption specimens shall be equal to the number of pipe provided for testing. The specimens shall be obtained from pipe that are acceptable as to strength and shall be taken from pipe used in making the strength test when that test is made. The specimens shall be marked with the number or identifying mark of the pipe from which they were taken. Each specimen shall have an area of 16 to 24 square inches and a thickness equal to the full depth of the pipe shell, and shall be free from visible cracks. Test Specimens

(b) Specimens shall be dried at a temperature of approximately 110° C. (230° F.) until no loss of weight is shown by successive weighings at intervals of not less than four hours. **Drying Specimens**

(c) The dried specimens shall be placed in a suitable receptacle, covered with distilled water or rain water, raised to the boiling point and boiled for five hours, and then cooled in water to a final temperature of from 15° to 20° C. (59° to 68° F.). When cool, the specimens shall be removed from the water, allowed to drain for not more than one minute, the superficial water removed by a towel or blotting paper, and the specimens immediately weighed. **Immersion and Reweighing**

(d) The balance used shall be sensitive to 0.5 g., when loaded with 1 kg. and weighings shall be read at least to the nearest gram. Where other than metric weights are used, the same degree of accuracy must be obtained. **Weighing Devices**

(e) The increase in weight of the boiled specimen over its dry weight shall be considered the absorption of the specimen and shall be calculated as a percentage of the dry weight. The results shall be reported separately for each specimen. **Calculation and Reporting of Results**

30. The absorption shall not exceed 8% for test specimens taken from pipe designed to be made of concrete having a compressive strength of 3,000 or more pounds per square inch, or 9% for test specimens taken from pipe designed to be made of concrete having a compressive strength of less than 3,000 pounds per square inch. Pipe shall be considered to meet these specifications for absorption when not less than 80% of the number of specimens tested, including any retested, meet the test requirements. When the initial absorption specimen from a pipe fails to meet these specifications, the absorption test shall be made on another specimen from the same pipe and the results of the retest shall be substituted for the original test results. **Test Requirements and Acceptability Under Absorption Tests**

31. Pipe will be considered ready for shipment when they meet the test requirements, or when tests of 6 by 12-in. cylinders (Section 27) show that the concrete has attained the strength assumed in the design of the pipe. **Minimum Age for Shipment**

32. Every manufacturer furnishing pipe under these specifications shall furnish all facilities necessary to carry out the tests herein provided. **Test Equipment**

VII. INSPECTION

33. All materials, processes of manufacture and finished pipe shall be subject to inspection and approval by an inspector employed by the consumer or purchaser. The manufacturer when so directed by the inspector shall have holes cut in such sections of the finished pipe (not exceeding one hole in every 50 sections delivered) as desired so that a proper inspection may be made of the quantity and placement of the reinforcement. If the pipes are tested for strength or absorption, inspection of the reinforcement shall be made on the pipe used for those tests, and in no case shall the total number of pipe cut open for inspection of reinforcement exceed the number to which the purchaser is entitled under the provisions of Sections 24 or 25. **Inspection**

34. Pipe shall be subject to rejection on account of failure to meet any of the specification requirements or on account of any of the following:

Causes for Rejection of Pipe

(a) Fractures or cracks passing through the shell, except that an end crack that does not exceed the depth of the joint, or a fracture that at its deepest point does not exceed the depth of the joint nor extend more than ten per cent around the circumference shall not be considered cause for rejection unless these defects exist in more than five per cent of the pipe inspected.

(b) Defects which indicate imperfect mixing and molding.

(c) Exposure of the reinforcement when such exposure would indicate that the reinforcement is misplaced.

TABLE I

DESIGNS OF STANDARD REINFORCED CONCRETE CULVERT PIPE FOR

Uniform Load of 2,000 Pounds Per Square Foot. Ultimate Compressive Strength of Concrete, 2,750 Pounds Per Square Inch

(f_c = 1,030 lbs.)

Internal Diameter of Pipe in Inches "d"	Minimum Thickness of Shell in Inches	Min. Dist. Center Reinforcement to Compressive Surface in Inches "t"		Minimum Area of Circular Reinforcement Square Inches per Lineal Foot of Pipe "A"			
				Cold Drawn Steel Wire f_s=27,500 lbs. sq. in.		Billet Steel Hard and Intermediate Grades f_s=20,000 lbs. sq. in.	
		Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe
12	2	1		1 Line .07		1 Line .09	
15	2¼	1⅛	1¼	1 " .09	1 " .08	1 " .13	1 " .12
18	2½	1¼	1½	1 " .12	1 " .10	1 " .17	1 " .14
24	3	1½	2	1 " .17	1 " .13	1 " .25	1 " .19
30	3½	1¾	2½	1 " .23	1 " .17	1 " .32	1 " .23
30	3½	2½	2½	2 "ea. .17	1 " .17	2 "ea. .23	1 " .23
36	4	3	3	2 " " .20	1 " .20	2 " " .28	1 " .28
42	4½	3½	3½	2 " " .23	1 " .23	2 " " .32	1 " .32
48	5	4	4	2 " " .26	1 " .26	2 " " .37	1 " .37
54	5½	4½	4½	2 " " .30	1 " .30	2 " " .42	1 " .42
60	6	5	5	2 " " .33	1 " .33	2 " " .46	1 " .46
72	7	6	6	2 " " .40	1 " .40	2 " " .56	1 " .56
84	8	7	7	2 " " .46	1 " .46	2 " " .65	1 " .65

TABLE II
DESIGNS OF
STANDARD REINFORCED CONCRETE CULVERT PIPE
FOR

Uniform Load of 2,000 Pounds Per Square Foot. Ultimate Compressive Strength of Concrete, 4,000 Pounds Per Square Inch

(f_c = 1,500 lbs.)

Internal Diameter of Pipe in Inches "d"	Minimum Thickness of Shell in Inches	Min. Dist. Center Reinforcement to Compressive Surface in Inches "t"		Minimum Area of Circular Reinforcement Square Inches per Lineal Foot of Pipe "A"			
				Cold Drawn Steel Wire f_s=27,500 lbs. sq. in.		Billet Steel Hard and Intermediate Grades f_s=20,000 lbs. sq. in.	
		Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe
12	1¾	⅞		1 Line .08		1 Line .11	
15	2	1		1 " .11		1 " .15	
18	2¼	1⅛	1¼	1 " .14	1 " .12	1 " .19	1 " .17
24	2⅝	1¼	1⅝	1 " .21	1 " .17	1 " .30	1 " .23
30	3	1½	2	1 " .29	1 " .21	1 " .38	1 " .29
30	3	2	2	2 " ea. .21	1 " .21	2 "ea. .29	1 " .29
36	3⅜	2⅜	2⅜	2 " " .26	1 " .26	2 " " .36	1 " .36
42	3¾	2¾	2¾	2 " " .30	1 " .30	2 " " .41	1 " .41
48	4¼	3¼	3¼	2 " " .34	1 " .34	2 " " .46	1 " .46
54	4⅝	3⅝	3⅝	2 " " .38	1 " .38	2 " " .52	1 " .52
60	5	4	4	2 " " .42	1 " .42	2 " " .59	1 " .59
72	5¾	4¾	4¾	2 " " .51	1 " .51	2 " " .71	1 " .71
84	6⅝	5⅝	5⅝	2 " " .60	1 " .60	2 " " .82	1 " .82

TABLE III
DESIGNS OF
EXTRA STRENGTH REINFORCED CONCRETE CULVERT PIPE
FOR

Uniform Load of 4,000 Pounds Per Square Foot. Ultimate Compressive Strength of Concrete, 2,750 Pounds Per Square Inch

(f_c = 1,030 lbs.)

Internal Diameter of Pipe in Inches "d"	Minimum Thickness of Shell in Inches	Min. Dist. Center Reinforcement to Compressive Surface in Inches "t"		Minimum Area of Circular Reinforcement Square Inches per Lineal Foot of Pipe "A"			
				Cold Drawn Steel Wire f_s=27,500 lbs. sq. in.		Billet Steel Hard and Intermediate Grades f_s=20,000 lbs. sq. in.	
		Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforce ment in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe
12	2½	1¼	1½	1 Line .11	1 Line .09	1 Line .15	1 Line .13
15	2¾	1⅜	1¾	1 " .15	1 " .12	1 " .21	1 " .17
18	3⅛	1⅝	2⅛	1 " .18	1 " .14	1 " .26	1 " .20
24	3⅞	2	2⅞	1 " .26	1 " .19	1 " .37	1 " .27
30	4⅝	2¼	3⅝	1 " .36	1 " .23	1 " .51	1 " .33
30	4⅝	3⅝	3⅝	2 " ea..23	1 " .23	2 "ea. .33	1 " .33
36	5⅜	4⅜	4⅜	2 " " .28	1 " .28	2 " " .40	1 " .40
42	6	5	5	2 " " .33	1 " .33	2 " " .47	1 " .47
48	6¾	5¾	5¾	2 " " .38	1 " .38	2 " " .53	1 " .53
54	7½	6½	6½	2 " " .42	1 " .42	2 " " .60	1 " .60
60	8¼	7¼	7¼	2 " " .47	1 " .47	2 " " .66	1 " .66
72	9⅝	8⅝	8⅝	2 " " .57	1 " .57	2 " " .80	1 " .80
84	11	10	10	2 " " .67	1 " .67	2 " " .94	1 " .94

TABLE IV

Designs of Extra Strength Reinforced Concrete Culvert Pipe for Uniform Load of 4,000 Pounds Per Square Foot. Ultimate Compressive Strength of Concrete, 4,750 Pounds Per Square Inch

(f_c = 1,780 lbs.)

Internal Diameter of Pipe in Inches "d"	Minimum Thickness of Shell in Inches	Min. Dist. Center Reinforcement to Compressive Surface in Inches "t"		Minimum Area of Circular Reinforcement Square Inches per Lineal Foot of Pipe "A"			
				Cold Drawn Steel Wire f_s=27,500 lbs. sq. in.		Billet Steel Hard and Intermediate Grades f_s=20,000 lbs. sq. in.	
		Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe	Circular Reinforcement in Circular Pipe	Elliptical Reinforcement in Circular Pipe and Circular Reinforcement in Elliptical Pipe
12	2	1		1 Line .14		1 Line .19	
15	2¼	1⅛	1¼	1 " .19	1 " .17	1 " .26	1 " .24
18	2½	1¼	1½	1 " .24	1 " .21	1 " .34	1 " .29
24	3	1½	2	1 " .35	1 " .27	1 " .50	1 " .39
30	3½	1¾	2½	1 " .47	1 " .34	1 " .66	1 " .48
30	3½	2½	2½	2 " ea..34	1 " .34	2 " ea..48	1 " .48
36	4	3	3	2 " " .41	1 " .41	2 " " .57	1 " .57
42	4½	3½	3½	2 " " .48	1 " .48	2 " " .67	1 " .67
48	5	4	4	2 " " .55	1 " .55	2 " " .76	1 " .76
54	5½	4½	4½	2 " " .62	1 " .62	2 " " .86	1 " .86
60	6	5	5	2 " " .68	1 " .68	2 " " .95	1 " .95
72	7	6	6	2 " " .82	1 " .82	2 " "1.14	1 " 1.14
84	8	7	7	2 " " .96	1 " .96	2 " "1.33	1 " 1.33

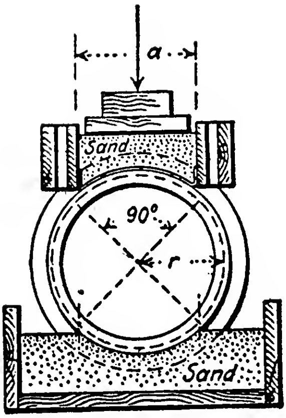
TABLE V

Minimum Strength of Reinforced Concrete Culvert Pipe

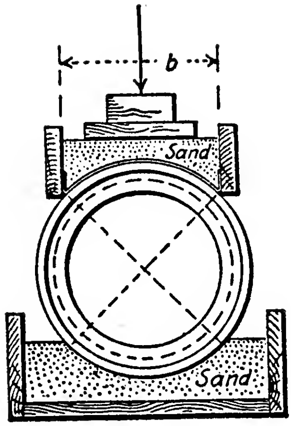
Pipe in Pounds Per Foot of Laying Length

Size of Pipe	Standard Reinforced Concrete Culvert Pipe				Extra Strength Reinforced Concrete Culvert Pipe			
	3 Edge Bearing		Sand Bearing		3 Edge Bearing		Sand Bearing	
	Cracking Load*	Ultimate Load	Cracking Load*	Ultimate Load	Cracking Load*	Ultimate Load	Cracking Load*	Ultimate Load
12"	1,600	2,000	2,400	3,000	3,200	4,000	4,800	6,000
15"	1,800	2,500	2,700	3,750	3,600	5,000	5,400	7,500
18"	2,000	3,000	3,000	4,500	4,000	6,000	6,000	9,000
24"	2,200	4,000	3,300	6,000	4,400	8,000	6,600	12,000
30"	2,500	5,000	3,750	7,500	5,000	10,000	7,500	15,000
36"	3,000	6,000	4,500	9,000	6,000	12,000	9,000	18,000
42"	3,500	7,000	5,250	10,500	7,000	14,000	10,500	21,500
48"	4,000	8,000	6,000	12,000	8,000	16,000	12,000	24,000
54"	4,500	9,000	6,750	13,500	9,000	18,000	13,500	27,000
60"	5,000	10,000	7,500	15,000	10,000	20,000	15,000	30,000
72"	6,000	12,000	9,000	18,000	12,000	24,000	18,000	36,000
84"	7,000	14,000	10,500	21,000	14,000	28,000	21,000	42,000

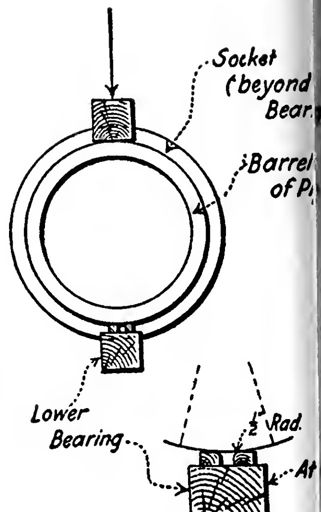
*At the cracking load there shall be, in the barrel of the pipe, no crack having a surface width of .01 inch or more for a length of one foot or more.

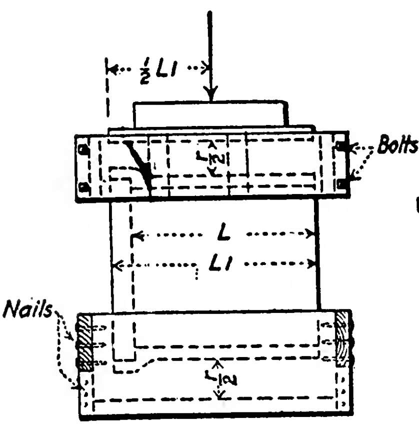


Bedding of Barrel.

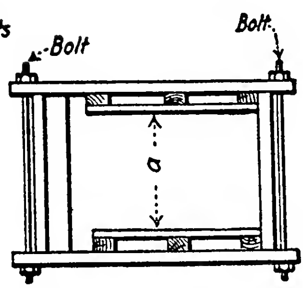


Bedding of Socket.





Side View.



Upper
Bearing Frame.

Fig. 2
Sand Bearings

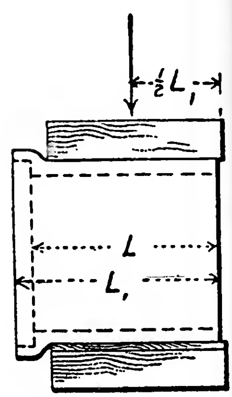
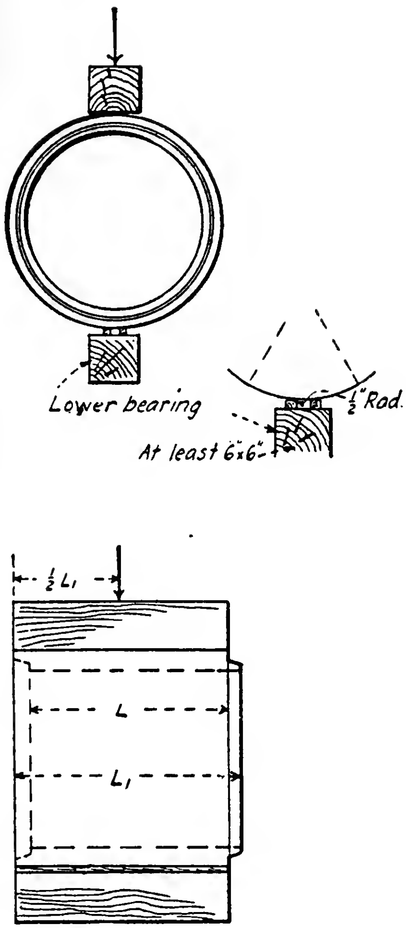
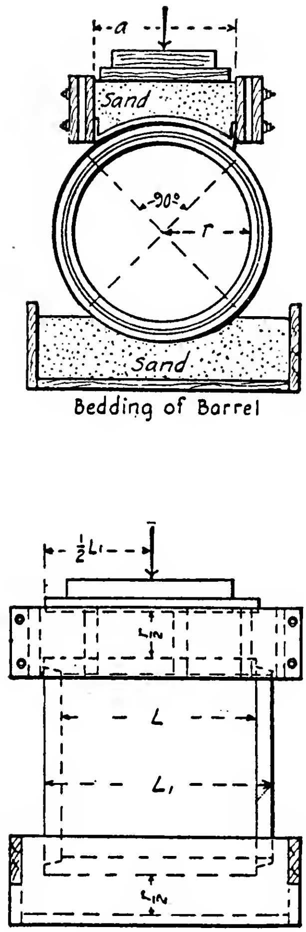


Fig. 3
Three Edge Bearings



Side View

Fig. 4
Three Edge Bearings



Side View

Fig. 5
Sand Bearings

(III) FLAT SLABS

The Sub-Committee submits, as information, the following method of design of girderless flat slabs for track construction.

DESIGN OF CONCRETE STRUCTURES

Regulations for Flat Slabs

In the design of girderless flat slabs for railroad locomotive loadings, moments shall be figured by the theorem of three moments for spans center to center of columns longitudinally, for such locomotives as are held standard on the railroad in question. In figuring these moments, such conditions of loading shall be assumed and figured as will give the maximum positive moments on the end spans and on the intermediate spans as well as the maximum negative moment over the support adjacent to the ends and over the intermediate supports. Conditions of loading for maximum shears shall also be figured.

The distribution of the live load moments shall be dependent on the distance center to center of tracks over which distance the live load may be considered distributed, where platforms do not intervene. In the four-way system that portion of the maximum positive moment included between the center lines of columns shall be considered as resisted by the two longitudinal half bands and the two diagonal bands in inverse proportion to the respective distances of the center of gravity of these bands to the center of live load moment on the panel; in the 2-way system this moment shall be considered as resisted by the two longitudinal half bands and the two mid-section bands in inverse proportion to the respective distances of the center of gravity of these bands to the center of live load moment on the panel, further taking into consideration the fact that the mid-section bands transfer their loads to the main bands directly.

The maximum negative live load moments along the center line of columns transversely as well as the positive moments at the centers of transverse bands shall be figured by the theorem of three moments using the equivalent uniform load for the condition of maximum moment longitudinally, with the condition of one track loaded, two tracks loaded, etc., to determine the various maximum moments transversely.

The moments due to the uniform and concentrated dead loads (train shed or canopy columns, signal bridge supports, etc.) shall then be figured and distributed as indicated above. The maximum live load moment plus the dead load moment plus the impact derived by the use of the formula $\frac{L.L.M.}{D.L.M. + L.L.M.}$ *L.L.M.*, shall be considered the moment to be resisted by the various bands. In figuring moments in either direction the amount of end restraint or the lack of it shall be given consideration.

For the reduction of the moment due to the shortening of the spans by means of the column design the various moments shall be modified by the coefficient $(1\text{-}C)^2$ where C is the ratio that the diameter of the column capital bears to the span length center to center of columns. The moments on diagonal bands in the 4-way system shall then be modified by the relationship between diagonal and direct span lengths and by the fact that two diagonal bands transfer the stresses at the center of span. In the two-way system there shall be provided reinforcement in the upper plane at the edges of the main bands, due to the continuity or restraint of the mid-section bands, by means of bending up at least ⅓ of the bars in the mid-section reinforcement or by the provision of short bars across the main bands and projecting into slab on either side.

In the case of skew or irregular panels, each diagonal shall be considered as resisting the moment of diagonal bands in inverse proportion to the distances center to center of columns of the respective diagonals.

For slabs with drop panels the slab thickness may be assumed as obtained from formula $t_2 = .02L\sqrt{w} + c$ for 4-way slab and $t_2 = .022L\sqrt{w} + c$ for 2-way slab where L = span length in feet center to center of the columns, w = total uniform load in pounds per square foot, and c = fireproofing protection to center of reinforcing steel; t_2 is in inches. The depth of drop panel shall not exceed 1½ times t_2.

For slab without drop panels the thickness may be assumed from $t = 0.024L\sqrt{w} + c$.

After the moments and shears have been found the slab thickness may be modified to meet these requirements.

In no case shall the slab thickness be less than $\frac{L}{32}$ for floor slab nor $\frac{L}{40}$ for roof slabs. Where the dropped panel is used the length of side or diameter shall not be less than $\frac{L}{3}$ nor greater than $\frac{L}{2}$ where L = span in feet center to center of columns. The column capital shall have a diameter or side of not less than $.2L$ nor more than $.25L$, preferably $.225L$.

The section to be figured for resisting the positive moment in any bands shall not exceed one-half of the span length in direction normal to that of span nor shall any steel other than that of the band be considered.

For negative moment the section to be considered shall not exceed the periphery of the drop panel, and only such reinforcement which extends 40 diameters beyond the column capital shall be considered as resisting the moment.

The compressive stress in the concrete resisting positive moment shall not exceed $.350\ f'_c$ and that resisting negative moment at the column capital shall not exceed $.400\ f'_c$.

The allowable shearing and bond stresses in flat slab design shall be similar to those in simple slab, but the critical section for such stresses may be taken at a point distant from the column capital equal to the depth of the dropped panel and in the slab at a point at a distance from the dropped panel equal to the depth of slab.

The point of inflection may be assumed as being $0.25\,L$ for slabs with dropped panels and $0.3\,L$ for those without dropped panels. Reinforcement shall be so designed as to carry the bars either side of the point of inflection at least 20 diameters for all bands. At least one-third of the bars used for positive reinforcement shall extend into the dropped panel not less than 40 diameters and preferably beyond the center line of columns. Where there are no dropped panels the bars shall extend at least to within one-eighth of the span center to center of columns; the main column reinforcement shall project into the slab to the top plane of slab reinforcement and be bent parallel to that plane.

Where girders support concentrations or walls and the steel reinforcement from the slab projects into the plane of such girders the latter shall be considered as taking its portion of the load of the slab between the girder and the main bands of reinforcement.

Appendix B

(3) SCIENCE AND ART OF CONCRETE MANUFACTURE

L. W. Skov, Chairman, Sub-Committee; J. A. Bohland, T. L. D. Hadwen, W. K. Hatt, Hans Ibsen, A. C. Irwin, D. B. Rush, E. E. Stetson, R. A. Van Ness.

In concrete construction certain results are often desired which will not be obtained in concrete from ordinary Portland cement under usual conditions. At times it is desired to place structures in service relatively soon after the concrete is placed. It may be desirable to secure concrete having unusual water tightness and small absorption, or the structural design may be such that high degree of workability is of importance.

As a consequence, cement manufacturers have developed several brands of special cements. Other companies have placed on the market materials in the form of admixtures to Portland cement.

In order to differentiate between these materials, definitions are submitted as follows:

SPECIAL CEMENTS AND ADMIXTURES

Quick Setting Portland Cement.—A Portland cement which stiffens and sets more quickly than ordinary Portland cement under similar conditions.

High Early Strength Cement.—A cement which will produce concrete having as high strength in a few days as ordinary Portland cement in twenty-eight days, used in the usual manner and proportions.

Supercement.—A trade name for a cement to which a small percentage of "Catacoll" (tannin) has been added with the gypsum at the time of grinding.

Admixture.—Any material, other than cement, water, or aggregate, added to the concrete mixture to effect certain changes in the properties of the concrete.

Integral Waterproofing.—Any admixture other than cement, water or aggregate added to the concrete mixture for the purpose of increasing the water tightness of the concrete.

Accelerators.—Any admixture other than cement, water, or aggregate added to the concrete mixture for the purpose of securing a more rapid hardening of the concrete.

The advantages claimed by the proponents of the various admixtures are:

1. That they increase the amount of colloidal material resulting from the hydration of cement.

2. That they lubricate the mass and allow the use of dryer mixes with consequent higher strength and density, thus waterproofing the mass.

3. That they repel moisture by breaking down capillary action and thus preventing absorption.

4. That they stimulate the process of hydration of the cement with consequent rapid hardening, waterproofness and greater strength.

5. That they fill the minute channels, voids or pores and so increase the workability.

The only published test data on the subject are meager and lacking in essential particulars.

Under these circumstances, the following conclusions seem justified:

1. The use of admixture should not be taken as a reason or excuse for neglecting proper inspection or for violation of the principles governing the production of good concrete.

2. The advantages claimed for admixtures may be secured by proper selection and proportioning of aggregates, water control, proper placing and curing and the use of enough cement paste to secure workability.

3. With aggregates not having enough fine material for workability this deficiency may usually be made good more economically than with proprietary admixtures.

As the special cements and admixtures are employed in the hope of securing special results, their use becomes a question of economics. Their effects on concrete over long periods of time are of utmost importance and are still to be determined.

Recently, a set of tests on special cements was completed by Prof. W. K. Hatt, at the University of Purdue. His tests were made for the purpose of studying change of lengths of neat cement beams, produced by other than temperature changes. Similar tests were made on neat cement beams, in which ordinary Portland cements were used. The ordinary Portland cements were included in the tests for the purpose of comparison. The results of Prof. Hatt's tests are given below in table form.

TABLE 'A

CHANGE IN LENGTH OF NEAT CEMENT BEAMS

Specimens 200 Days Old

Beams 2"x2"x24" Neat Cement

Cement	A	B	C	D	E	F	G	H
Maximum Expansion in Water	.1035	.0809	.0689	.1846	.0492	.0689	.0809	.0969
Maximum Contraction in Air	.1701	.2417	.2087	.0903	.2015	.2241	.2296	.3707
Total Range	.2736	.3226	.2776	.2749	.2507	.2930	.3105	.4676

Values in Percent

Brands A.B and C, Normal Portland Cements.
G, Special " "
D,E,F and H, High Strength "

Table A shows linear change of neat cement beams 200 days old. Table B shows the strength tests on the same cements when mixture 1-3 with standard Ottawa sand. Table C shows the physical properties.

By referring to Table A it will be noted that the linear contraction for cement H in air was .3707 per cent.

Cement B, the ordinary Portland cement having the greatest linear contraction, gave .2417 per cent under similar conditions. This shows a difference of 53 per cent linear contraction between cements B and H.

TABLE B

STRENGTHS of CEMENTS used in LINEAR CHANGE INVESTIGATION

Mix
1-3 Standard Ottawa Sand

Tension Specimens.
1"x1" Standard Briquettes

Compression Specimens.
2"x 4" Cylinders.

Cement	1 Day		3 Days		28 Days		120 Days		180 Days	
	Tensile Strength	Comp. Strength	Tensile Strength	Comp. Strength	Tensile Strength	Comp. Strength	Tensile Strength	Comp. Strength	Tensile Strength	Comp. Strength
A	80	417	180	637	353	2,000	370	2,650	380	2,875
B	55	392	177	691	333	1,968	328	2,329	335	2,315
C	90	425	180	806	422	2,018	430	2,865	420	3,070
D	365	3,490	395	4,225	410	4,360	443	4,910	458	4,440
E	185	1,011	270	1,833	357	3,530	378	4,640	377	4,840
F	167	1,041	283	1,622	407	2,870	465	3,800	460	3,900
G	45	281	113	663	298	1,677	365	2,040	360	2,369
H	255	1,785	315	2,564	400	4,350	420	4,450	407	4,500

Values in Pounds per Sq. Inch.

TABLE C

PHYSICAL TESTS of CEMENTS used in LINEAR CHANGE INVESTIGATION

Cement	A	B	C	D	E	F	G	H
Per cent Water Normal Consistency	22	22	23	23	24	25	22	28
Volume Weight Loose	1.168	1.162	1.231	1.230	1.194	1.159	1.290	1.135
Volume Weight Rodded	1.371	1.336	1.407	1.408	1.323	1.310	1.457	1.207
Per cent Voids (Rodded)	57.9	56.3	54.6	54.7	55.6	57.8	51.9	60.2
Specific Gravity	3.11	3.06	3.10	3.11	2.98	3.10	3.03	3.03
% Retained on 200 Mesh Sieve	18.8	15.6	13.0	15.1	12.8	3.6	15.9	2.2
Steam Test for Soundness	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
Time of Set Initial	3 hrs. 25m.	2 hrs. 55m.	3 hrs. 25m.	4 hrs. 55m.	1 hr 45m	2 hrs. 10m.	3 hrs. 10m.	2 hrs. 30m.
Time of Set Final	5 hrs. 20m.	5 hrs 0m	5 hrs 30m.	6 hrs 30m.	3 hrs 30m.	4 hrs 30m.	5 hrs 40m.	4 hrs 20m.

MOISTURE AND BULKING OF AGGREGATE

In applying the water-cement ratio methods, it is necessary that the amount of water added to the mix for each sack of cement be corrected for the amount of water introduced or subtracted by the aggregates. Usually the fine aggregates—and often the coarse aggregates—carry important amounts of water which must be determined and reckoned with the water to be added at the mixer.

Fine aggregates bulk considerably, depending upon the moisture content and somewhat upon the method of measurement. Once the desired mix is established, changes in the bulking of the sand will produce somewhat different true proportions. Basic proportions, determined by actual trial to cover a certain kind and grading of aggregates, are usually given in terms of dry rodded volumes. These volumes, must, therefore, be corrected for bulking.

Probably the most accurate method to find the moisture content of an aggregate is to weigh a sample before and after drying. The difference between these weights is the contained moisture content.

Several methods have been tried and others suggested to determine moisture content more quickly. The principles of these methods may be classified as follows:

1. Conductivity Method.—The difference in electrical conductivity from variations in moisture content is measured by the McIlvaine Moisture Meter, a device originally developed to find moisture content of foundry sands. (See Fig. 1.)

This instrument gives quicker results than any other known method or apparatus, but the results are not accurate for the coarser sands used in concrete making.

2. Specific Gravity Methods.—Several such have been developed to determine the moisture content in sands based on weights in damp loose condition and when inundated; others involve variations in buoyancy specific gravity of the standardized salt solution when diluted with the free water contributed by an inundated sand sample.

(a) A unit volume of loose, damp sand is weighed and then inundated in a container by pouring in water until the container is level full. The weight of inundator and contents is taken. The difference between the weight just taken and that of inundator full of water alone represents the difference in weight between the absolute volume of the sand and an equal volume of water. Therefore, this difference divided by (specific gravity minus 1.00) will give the absolute volume. Absolute volume times specific gravity equals the weight of dry sand. This weight subtracted from the weight of the damp, loose sample gives the weight of water carried by the sample. The specific gravity of sand may be taken as 2.65.

(b) The Hydrometer Method.—The Hydrometer (Fig. 1) is calibrated to read in gallons of water per 100 lb. of aggregate. It is used as follows. Make up a saturated salt solution, and place 1 qt. of it in a 2-qt. jar. The hydrometer should read zero for this solution. Add a 1515-gram sample of damp sand to the solution in the jar and stir vigorously for 3 min. The salt solution is thus diluted by the moisture in the sand and its specific gravity lowered. The amount of water introduced by the sand is read in gallons per 100 lb. directly on the calibrated scale of the hydrometer. The percentage of moisture then is:

$$p = G \times C$$

where p = percentage of moisture by weight of damp sample.
G = hydrometer reading in gallons per 100 lb. of damp sand.
C = a constant, or the pounds of water in a gallon.

p is then converted to percentage of moisture by weight of the dry sand contained in the damp sample.

3. Volumetric or Displacement Method.—A given weight of dry sand will always displace the same volume of water regardless of its grading assuming the specific gravity is constant. In other words, the absolute volume of equal weights of the same sand remain constant regardless of the size of the sand particles. If, then, the displacement of the given weight of dry sand is compared with the displacement of the same weight of damp or wet sand, the moisture content of the damp or wet sand can be computed. Several methods have been developed to apply this principle.

(a) Chapman Flask (see Fig. 1).—The flask is filled with water to the 200-cc. mark. A 500-gram sample of sand dried to constant weight is then poured into the flask through the funnel, the flask well shaken and the displaced water noted in the flask. The operation is then repeated using the same weight, that is, 500 grams of damp sand. The percentage of moisture is then calculated from the formula:

$$p = \frac{D-C}{W-D}$$

where p = ratio by weight, water to dry sand.
D = weight by water displaced by damp sample of weight W.
C = weight of water displaced by dry sample of weight W.
W = weight of sample (dry, surface dry, or damp).

(b) Portland Cement Association Cylindrical Container (see Fig. 1). This device has a gage glass to show the water level. The container is first filled with water up to the zero mark on the gage. A spiralled wire is then inserted into the container and a 200-gram sample of dry sand poured in at the top. The wire is then gradually withdrawn, agitating the sand while so doing. The volume of displaced water is then read. The operation is then repeated using the same weight, 200 grams of damp sand, and recording the displacement. The ratio of moisture is finally calculated from the same formula as for the Chapman Flask, namely:

$$p = \frac{D-C}{W-D}$$

(c) Graduate Glass.—A 500 cc. graduate glass or the Chapman Flask can be used in a very simple manner as follows: A 500-gram sample of dry sand and 200 cc. of water are placed in the graduate. The volume of water above the sand and also the volume of inundated sand is read. With 200 cc. of water in the graduate, pour in damp sand until the graduate is filled to the same mark as that of the inundated 500 grams of dry sand. Read the volume of water above the sand. The difference in volume of water above the sand obtained with dry sand and that obtained with damp sand multiplied by 100 and divided by 500 gives the percentage of moisture content by weight. This percentage is too great by the percentage of absorption of the dry sand. If the Chapman Flask is used, the only difference in method is in the quantity of sand used in the tests.

(d) The same principles as above have been applied by Mr. Marquardsen to an apparatus that employs a movable plunger of small internal diameter that can be set at zero and this enables the operator to read volumes of displaced water directly. This apparatus is described in *Engineering and Contracting,* September, 1927.

(e) The graduate may be dispensed with by using a measure of known capacity and weighing the overflow water resulting from filling the measure with damp sand. The weight of the overflow water is compared with the weight of dry sand that would just fill the measure when inundated.

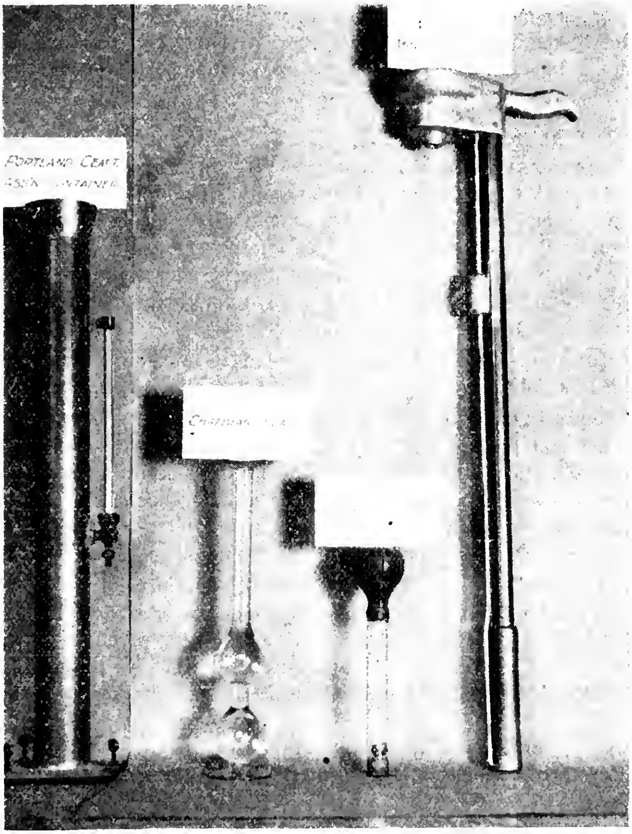


FIG. 1

(f) THE "HUNT" METHOD*.—Provide a measuring can of a volume of 1/10 cubic foot, and of such dimensions as to be one foot deep. Take a sample of sand as received on the job. Dry enough to fill the measuring can somewhat over one-half full. Clean out can and fill one-half full of water.

*Method used by the Robert W. Hunt Company.

Slowly pour dry sand into the water until the can is one-half full of sand and record water level by measuring distance down from top of can. Clean out can and again fill one-half full of water and slowly pour sand, as received on the job, into the measuring can until one-half of the can is filled with sand; again record water level. The difference between the two water level readings, in decimals of a foot, when multiplied by fifteen, gives the number of gallons of water per cubic foot of the sand as received on job.

NOTE.—By marking the can at the one-half full level and using a scale graduated to tenths and hundredths, the two water level readings can easily be obtained by taking measurements from top of can to surface of the water levels.

4. DRYING TO CONSTANT WEIGHT.—This method is direct and very simple in so far as its principles are concerned. The sample of the damp sand is weighed, dried out and weighed again. The difference in the weight of the wet sample and of the same sample after drying is the weight of water contained in the sample. If it is not convenient to provide a fire for drying out the sample, denatured alcohol may be poured into the sample and burned as the sample is stirred. The alcohol may be poured into the sample and burned out until the sample is completely dry.

5. BULKING.—The bulking factor due to moisture content may be determined as follows:

1. DRYING OUT AND MEASURING.—A measure full of damp, loose sand is dried out and then rodded back into the same measure. It will not fill the measure. The distance from the top of the measure to the top of the dried out sample in the measure, compared with the height to which the dry sample fills the measure will give the bulking factor. This determination can be made at the same time as the determination of the moisture content under No. 4 above.

2. INUNDATED VOLUMES.—Since the amount of sand in an inundated volume is constant, it follows that a comparison of the volume produced by inundating the same volume of loose, moist sand will give the bulking effect of looseness and moisture. This is illustrated as follows:

> Inundate a known volume of dry rodded sand and note the height of the sand in the vessel. Inundate in the same vessel the same volume of moist sand measured loose in the same container as the dry rodded sand. Note the height of the sand in the container. The difference in height compared with that of the inundated dry sand gives the bulking per cent.

3. WEIGHT METHOD.—Weigh a measure full of dry rodded sand. Fill the same measure full of loose moist sand and weigh. Correct this weight for moisture and absorption and compare with the weight of the dry rodded sand. The ratio gives the bulking factor.

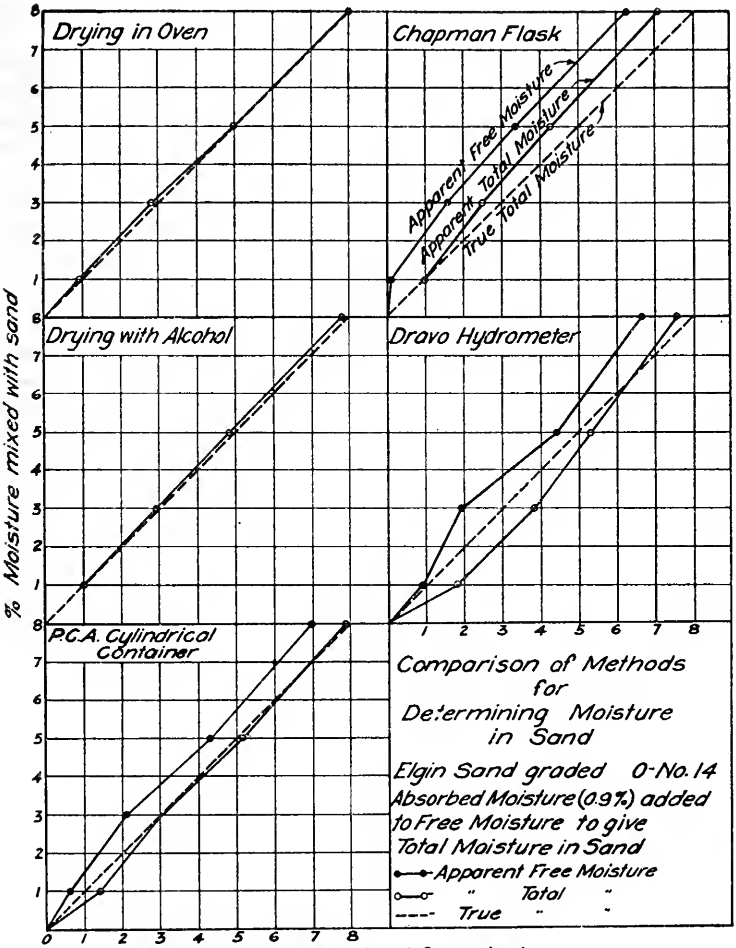


FIG. 2

Above tests made by W. R. Johnson, Research Dept., P.C.A.

Conclusions

Moisture in Aggregate

A comparison of all methods indicates that the best results are obtained with those methods requiring the simplest manipulation; for example, the drying out method gives the most accurate results for determining the moisture.

For moisture determination by the displacement methods, Chapman Flask, P.C.A. Container, etc., rank next in point of accuracy. The specific gravity method with the Hydrometer ranks next in accuracy, and the electrical conductivity method is too inaccurate. Fig. 2 shows a comparison of the accuracy of several methods of determining moisture.

The "Hunt" method by volume and displacement, as noted in 3(f), however, has been used very advantageously on a large number of jobs, both large and small, and although very simple in application, has proven sufficiently accurate for all practical purposes.

Bulking of Aggregates

Any of the methods given are sufficiently accurate for determination of bulking. The specifications require that a workable mix be always obtained; that is, the proportion of fine and coarse aggregate can be changed to suit job conditions so long as the water-cement ratio is carefully preserved. In other words, the bulking can be taken care of by an experienced inspector who is able to judge the workability from the behavior of the concrete. A close check should, however, be kept on the moisture content of the aggregates to insure as little variation as possible in the water ratio.

Appendix C

(6) GENERAL PRACTICES FOR WATERPROOFING RAILWAY STRUCTURES

J. A. Lahmer, Chairman, Sub-Committee; G. E. Boyd, H. M. Brown, E. Duncan, J. A. Parant, W. L. Roller, F. E. Schall, S. E. Smith, E. E. Stetson.

Considerable time has been devoted to the study and consideration of the data on the Waterproofing of Railway Bridge Decks, obtained through a questionnaire and submitted with the report of last year (Vol. 29, pages 634-40).

Your Committee believes that the specifications for Waterproofing and Drainage of Solid-Floor Railway Bridges, presented by Committee XV and adopted by the Association at its convention in 1927, marks an important step toward establishing uniformity in practice. Your Committee, however, feels that, in collaboration with Committee XV, the several types of waterproofing recommended in this specification may be condensed and that additional study on Special Treatment of Flashings, Construction and Expansion joints and other related matters may be made in the interests of economy and in practice. Your Committee reports progress in this subject.

The following answers to the questionnaire received last year, were inadvertently omitted from the published report heretofore referred to (Vol. 29, pages 634-40). For convenient reference, these are submitted and the explanatory notes covering the various types of waterprofing are repeated.

Due to the lack of a recommended practice for waterproofing and damp proofing of railway structures other than bridge decks, your Committee fails to find any general practice for this class of work. A questionnaire form on this subject has been prepared to obtain sufficient data on which to base a recommended practice. From the data already at hand, it is believed that much valuable information on this subject will be obtained by this method.

Abstract of Answers to Questionnaire Regarding Waterproofing of Railroad Structures (Bridges)

(1)	(2)	(3)	(4)	(5-A)	(5-B)	(5-C)
Long Island	Yes; shall in future	Types "A" and "F"	Either on horizontal surfaces. Asphalt on inclined surfaces which are too steep for coal tar	Concrete on flat surfaces	Carry concrete (reinf.) over the edge and down the required distance	Locate expansion joints at as high a point as possible and stop the membrane, using flexible joint if necessary. At construction joints use sufficient reinforcement to avoid cracks
Missouri Pacific	No waterproofing since specifications adopted	Types "A" and "F." Tops of slabs and rear walls of abutments are given two coats of hot asphalt	Asphalt	Membrane waterproofing, when used, is protected by 1½ inches of reinforced concrete	Concrete protection carried over bridge ends on vertical surface	Expansion provided by bent copper plates
New York Central Lines (N.Y.C. R. R.-Buffalo & East)	No	Usually type "A" for bridge floor; "B" for subways or any structure below water line. Backs of abutments coated with coal-tar pitch	Both	Reinforced concrete unless work is done under traffic, when brick is generally used	Same as elsewhere except that at expansion ends a steel plate, attached to bridge but free to move over back wall, is used as a support	At expansion joints a flexible copper strip is provided which permits sufficient movement to compensate for change in temperature. At points of reverse bending a strip of oiled paper about one foot wide is inserted both under and over the waterproofing membrane along the line of support. No special treatment is necessary at any other construction joint.
New York Central (West of Buffalo)	Yes	Type "A" in highway bridge floors and for back of retaining walls. Type "E" with mastic protection on railway bridge floors	Asphalt	Brick for type "A" when used on back of retaining walls, etc. Field mixed asphalt mastic for type "E"	No protection. None necessary with our design	Have no standard method. Each case worked out to meet construction details
New York Central Lines (C.C.C. & St. L.)	No. Some slight differences	A, E and F of A. R. E. A specifications and B, C and D of N. Y. Central specifications	Both	Usually concrete	No armor coat. Additional plies added	Expansion joints omitted when length is not more than 200 feet. Copper joints and flashing used where expansion joint is necessary
New York, Chicago & St. Louis	Yes	Types "C" and "D"	Both	Prepared mastic or asphalt block	Do not protect	Form loop in membrane and use expansion joint in protection
New York, New Haven & Hartford	No. No standard	Type "D"	Both	Hand mixed mastic and brick	Usually brick	No standard detail. Have used copper expansion joints in some cases

Type A. Two layers of as halt treated cotton fabric and three moppings of asphalt.
Type B. Three layers of asphalt-treated cotton fabric and four moppings of asphalt.
Type C. Two layers of asphalt-treated felt, one middle layer of asphalt-treated cotton fabric, and four moppings of asphalt.
Type D. Two layers of pitch-treated felt, one middle layer of pitch-treated cotton fabric, and four moppings of coal-tar pitch.
Type E. Four layers of asphalt-treated felt, one middle layer of asphalt-treated cotton fabric, and six moppings of asphalt.
Type F. Four layers of pitch-treated felt [illegible]

Abstract of Answers to Questionnaire Regarding Waterproofing of Railroad Structures (Bridges)

(1)	(2)	(3)	(4)	(5-A)	(5-B)	(5-C)
Northern Pacific	Yes	Type "A"	Asphalt	$2\frac{1}{2}$ inch layer of concrete reinforced with netting or expanded metal	Reinforced concrete	Provide an opening protected by hood or cover
Pere Marquette	Yes	Type "A"	....	Concrete	Concrete	....
Pennsylvania	No. Call for particular make of waterproofing or equal as part of general contract. Waterproofing is applied in accordance with manufacturer's own specifications with understanding they will be responsible for integrity of material	Types "A" and "B"	Have used both asphalt and coal-tar products. Latest ideas are for exclusive use of asphalt	Have used brick, tile, asphalt blocks and armor coating of reinforced concrete, wire mesh to weigh not less than ten pounds per square. Now experimenting with "Elastite," a Philip Carey product	In protection of membrane it is also carried up the sloping or vertical surfaces with material outlined as in "A"	Avoid wherever possible membrane at construction or expansion joints. When necessary to carry membrane at this point it is sometimes done by using inverted trough of lead or copper with concrete insert
Philadelphia & Reading	No	Types "A" and "B." Also asphalt mastic where not possible to use fabric	Asphalt products	Concrete	Do not carry membrane over end of bridge to vertical surface but flash in groove with elastic cement	At construction joints, membrane is carried across joint without special provision. At expansion joint an opening is left and covered with steel plate. Membrane is stopped in flashing groove each side of plate. At joint, concrete is raised so steel plate is above level of the other concrete surface
Seaboard Air Line	Yes	Generally "A," "B" and "C"	Asphalt generally	No experience on railroad bridges. On highway bridges, generally use mastic and street paving	No cases	No cases for railroad bridges. For highway, allow slight fullness of material over joints

Type A. Two layers of asphalt-treated cotton fabric and three moppings of asphalt.
Type B. Three layers of asphalt-treated cotton fabric and four moppings of asphalt.
Type C. Two layers of asphalt-treated felt, one middle layer of asphalt-treated cotton fabric, and four moppings of asphalt.
Type D. Two layers of pitch-treated felt, one middle layer of pitch-treated cotton fabric, and four moppings of coal-tar pitch.
Type E. Four layers of asphalt-treated felt, one middle layer of asphalt-treated cotton fabric, and six moppings of asphalt.
Type F. Four layers of pitch-treated felt, one middle layer of pitch-treated cotton fabric, and six moppings of coal-tar pitch.

REPORT OF COMMITTEE XVI—ECONOMICS OF RAILWAY LOCATION

F. R. LAYNG, *Chairman;*
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HADLEY BALDWIN,
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C. P. HOWARD,
E. E. KING,
FRED LAVIS,
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W. H. WINTERROWD,
J. C. WRENSHALL,
F. E. WYNNE,
M. A. ZOOK,

Committee.

*Died, November 14, 1928.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Continue the study of economics of railway location as affected by the introduction of electric locomotives (see Appendix A).

(2) Prepare in form for convenient use, essential operating data required for making relative comparisons of values for studies of line and grade revisions to meet modern operating requirements (see Appendix B).

Action Recommended

1. That the report, Appendix A, be approved for publication in the Manual.

2. That the progress report in Appendix B be received as information.

Recommendation for Future Work

1. Revision of the Manual.

2. Continue the study of economics of grade revision as affected by the introduction of electric locomotives, collaborating with Committee XVIII—Electricity.

3. Continue the study of the relative merits of ruling grades lighter than 0.4 per cent, in the light of modern operating requirements.

4. Continue the study of the relative merits of increasing tonnage by the reduction of ruling grades or by the introduction of locomotives with greater tractive power, with consideration of momentum grades and the development of the locomotive booster.

Bulletin 314, February, 1929.

5. Prepare in form for convenient use, essential operating data required for making relative comparisons of values for studies of line and grade revisions to meet modern operating requirements.

6. Study and report on the extent train resistance is increased when trains are operating on flexible rails as compared with same operation with stiffer rails, collaborating with Committee IV—Rail and Committee XXI—Economics of Railway Operation.

7. Outline of work for ensuing year.

Respectfully submitted,

THE COMMITTEE ON ECONOMICS OF RAILWAY LOCATION,

F. R. LAYNG, *Chairman.*

Appendix A

(1) ECONOMICS OF RAILWAY LOCATION AS AFFECTED BY THE INTRODUCTION OF ELECTRIC LOCOMOTIVES

F. E. Wynne, Chairman, Sub-Committee; S. E. Armstrong, W. L. R. Haines, Fred Lavis, L. O. Sloggett.

ECONOMICS OF RAILWAY LOCATION—POWER

Electric

(1) In choosing an electric locomotive to perform a specified service, the first step is to determine the weight required on its drivers. The governing factor may be either starting or running conditions on the ruling grade. Hence, it is necessary to find the weight on drivers for both starting and running and then use the larger value.

(2) For starting* the formula is:

$$W_D = \frac{(20_G + 100a + R_T)\ (T + W_C),}{2000A_S - 20G - 100a - R_D}$$

and for running* the formula is:

$$W_D = \frac{(20G + R_T)\ (T + W_C)}{2000A_R - 20G - R_D}$$

where W_D = tons total weight on locomotive drivers.
W_C = tons total weight on locomotive non-driving axles.
T = tons total weight of train (excluding locomotive).
G = per cent ruling grade, including curve.
a = miles per hour per second acceleration rate.
R_T = pounds per ton train resistance for cars and non-driving axles of locomotive.
R_D = pounds per ton locomotive resistance for weight on drivers.
A_S = starting coefficient of adhesion of drivers.
A_R = Running coefficient of adhesion of drivers.

*See pages 807 and 813 of the 1921 issue of the Manual regarding coefficients of adhesion.

(3) Where a locomotive type with all weight on drivers is suitable for the service, the term $W_C = O$ and then in both of these equations the numerator of the second term represents locomotive draw-bar-pull.

(4) The next step is to find the capacity of the locomotive. Practically all electric locomotives can develop sufficient tractive effort to slip the drivers on sand, but this imposes an overload on the electrical equipment. The limit for the frequency and duration of overloads is in the heating of the electrical apparatus. In general the excess heat developed during the overloads produced by acceleration or short ruling grades may be stored temporarily and later dissipated under the easier running conditions. On long ruling grades it is unsafe to work the locomotive much above its rated continuous capacity.

(5) An approximation of the locomotive capacity for the ruling grade is obtained by use of the formula:

$$HP = \frac{TE_R \times MPH_R}{375}$$

where, HP = horsepower developed by the locomotive.
TE_R = total pounds tractive effort to move the locomotive and its train on the ruling grade.
and, MPH_R = miles per hour desired on the ruling grade.

Using the same symbols as in (2):

$TE = (20G + 100a + R_D)\ W_D + (20G + 100a + R_T)\ (T + W_C)$ is the general equation for tractive effort. On level track, $G = O$. At balancing speed, $a = O$. When a locomotive has all weight on drivers, $W_C = O$.

(6) For extreme accuracy in applying electric locomotives and predetermining their service performance, it is necessary to have locomotive performance characteristic curves and motor heating and cooling curves in addition to the detailed profile and alinement of the track, schedules, train weights, and local requirements (such as speed restrictions, axle loading limits, etc.). In the absence of characteristic and heating curves, the capacity as approximated in (5) should be given certain checks.

(7) The starting tractive effort should be not more than 50 per cent greater than the running tractive effort on the ruling grade. If more than one hour is required to ascend the ruling grade at the desired speed, the tractive effort on the ruling grade should not exceed the rated continuous tractive effort. If there is a continual rise at slightly varying grade and requiring more than one hour, the continuous rated tractive effort may be the average required for the entire climb, provided the tractive effort on the ruling grade does not exceed the continuous tractive effort by more than 5 per cent for 15 minutes or by more than 10 per cent for 5 minutes. If the profile is rolling with terminals at substantially the same elevation and less than forty minutes is required to ascend the longest continuous grade, the rated continuous tractive effort may be not less than 80 per cent of that for the ruling grade or not less than 90 per cent of the average for the whole ascent of this longest continuous grade. The largest value of continuous tractive effort indicated by the foregoing checks should be taken as the required locomotive's continuous tractive effort (TE_C).

(8) At this point speed-tractive effort curves of the locomotive are required. There are four general types of electric locomotives whose characteristics differ more or less. Typical curves for each of these major types are shown in Fig. 1, 2, 3 and 4. From these general curves the continuous horsepower rating of the locomotive may be determined. In (5) the speed on the ruling grade (MPH_R) was chosen and the tractive effort (TE_R) calculated for that grade. In (7) the continuous tractive effort (TE_C) was found. Find the ratio $\frac{TE_R}{TE_C}$, expressed in per cent. Locate this per cent TE value on the general curve in (8) and read the corresponding per cent MPH value (P) which is the speed on the ruling grade, MPH_R. Then the speed at the continuous rating, MPH_C is equal to $\frac{MPH_R}{P}$.

The locomotive horsepower continuous capacity is

$$HP_C = \frac{MPH_C \times TE_C}{375}$$

(9) The relations between locomotive weight and capacity are affected by both mechanical and electrical design so that a suitable locomotive of the required capacity (HP_C) may weight inherently considerably more or even less than as calculated from (2). Comparison of the weight as found in (2) should be made with published information regarding electric locomotives of similar capacity, speed and mechanical design which have been built. This will indicate whether the required locomotive will be heavier inherently than the required minimum or will have to be ballasted to get sufficient adhesive weight.

(10) The third step is to determine the sufficiency of the locomotive, of the selected weight and capacity, for meeting the required schedules. The continuous speed and tractive effort being known from (7) and (8), a locomotive performance curve may be constructed for the specific study which is being made. The continuous speed, MPH_C, and tractive effort, TE_C, are the 100 per cent values of the general curve of the locomotive type desired. Fig. 1, 2, 3, or 4. Assume any other tractive effort value, TE_Y. This is P_Y per cent of TE_C. $P_Y = \frac{TE_Y}{TE_C}$. At P_Y tractive effort, the general curve shows P_X per cent speed and $MPH_X = P_X\,(MPH_C)$. Therefore, TE_Y and MPH_X are simultaneous values for the specific performance curve. Fig. 5 shows such a curve constructed from Fig. 2 for a 3300 P.H. electric locomotive having a continuous tractive effort of 50,000 lb.

(11) From the profile and alinement of the railway, the tractive efforts for all parts of the entire run may be calculated and by the use of the locomotive curve, similar to Fig. 5, the corresponding running speeds and times may be determined. To the overall time thus obtained must be added the time necessary to start and stop the train, time standing at intermediate points, and time lost due to speed restrictions in order to get the total elapsed time for the run. On descending grades where train speed is not determined by the locomotive characteristics, the maximum speed should never exceed that shown on the locomotive curve.

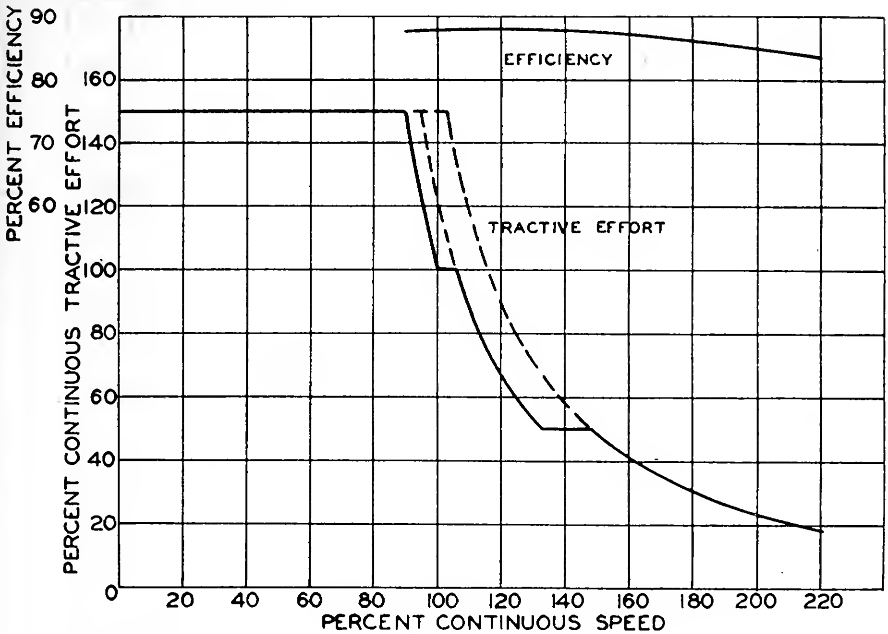


Fig. 1—Direct Current. Solid Lines Show Normal Operating Range, Dotted Lines Show Permissible Range.

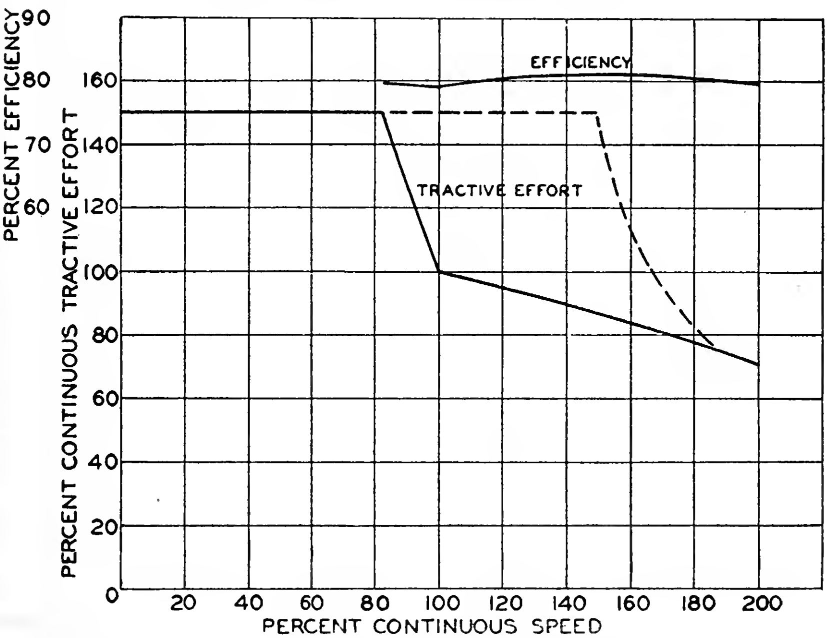


Fig. 2—Alternating Current Series. Solid Lines Show Normal Operating Range, Dotted Lines Show Permissible Range.

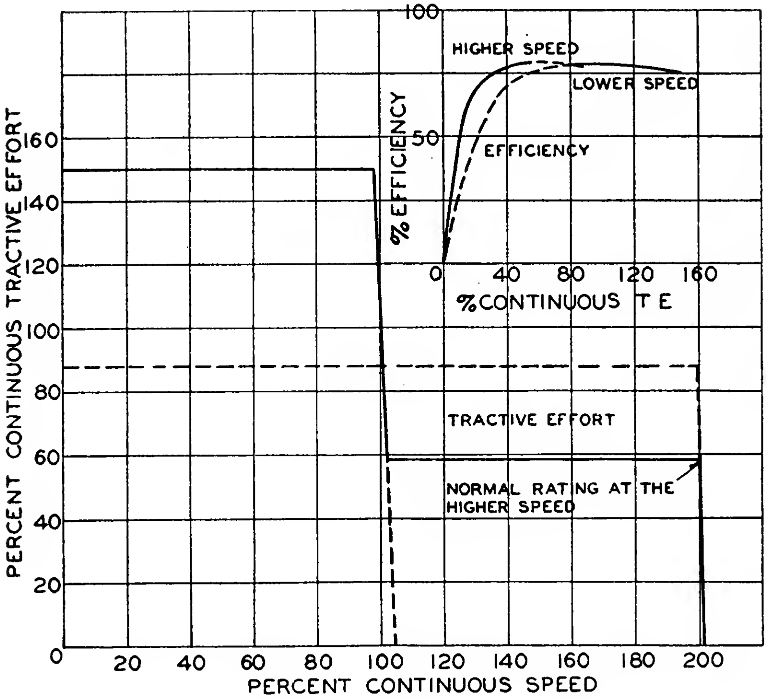


Fig. 3—Alternating Current Split Phase. Curve Is Drawn for Two-Speed Locomotive, One Speed Double the Other. Solid Lines Show Normal Operating Range, Dotted Lines Show Permissible Range, All in Terms of the Lower Rated Speed and Tractive Effort.

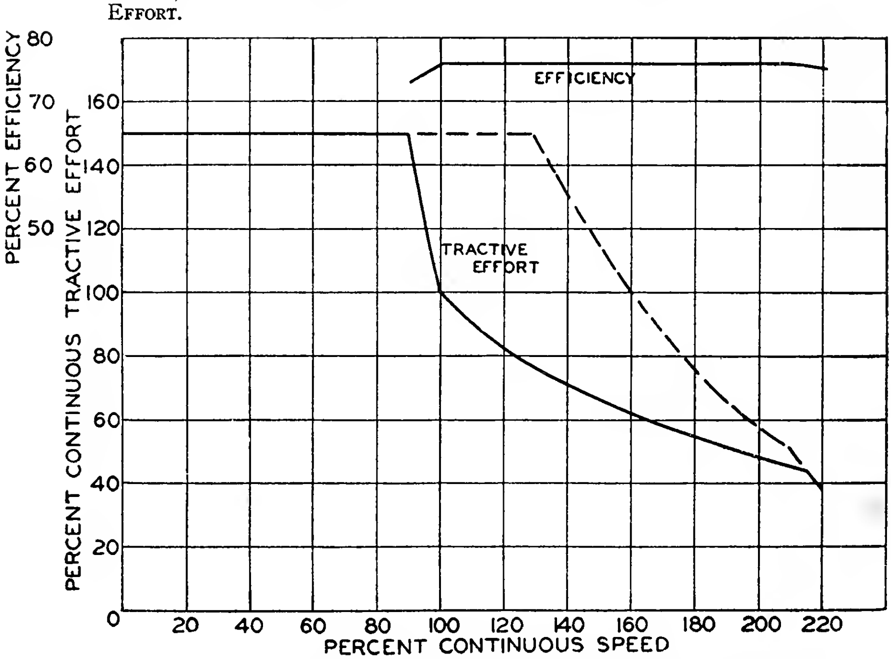


Fig. 4—Alternating Current Motor Generator. Solid Lines Show Normal Operating Range, Dotted Lines Show Permissible Range.

(12) In case the total time found from (11) is too great or too small, it becomes necessary to increase or decrease the rated speed and horsepower of the locomotive in order to have a correct application. The new correct values may be determined by multiplying the rated speed and horsepower of the locomotive used in (11) by the ratio found by dividing the running time of (11) by the desired running time.

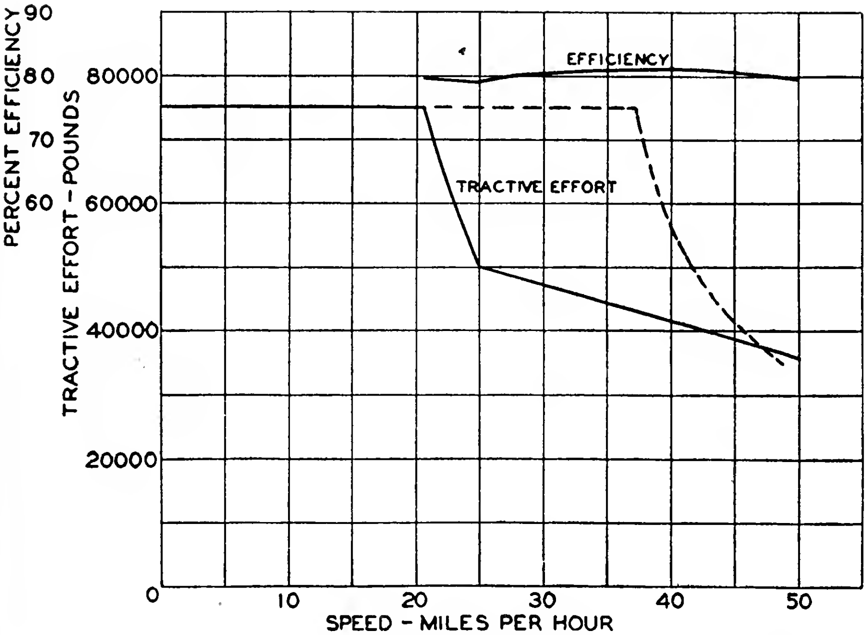


FIG. 5—CHARACTERISTIC CURVE A.C. LOCOMOTIVE—SERIES MOTORS 3,300 H.P. CONTINUOUS RATING.

(13) The final step is to determine the quantity of electrical energy which must be delivered to the locomotive to perform the required service. Fig. 1 to 5 show overall efficiency curves constructed by dividing the output at the tread of the drivers by the input including that for all auxiliaries, such as air compressors, blowers, lights, heaters and control. There is a marked difference in the efficiencies of the several locomotive types. However, this is of minor importance in computing economics of electrification because of the inherent relations existing among the other elements of the several electrification systems. The overall economy of the system with the least efficient locomotives generally equals and may even exceed that which can be secured with the most efficient locomotives.

(14) From (11) the tractive effort, speed and time of operation for each section of the line are known. For any section the locomotive output is:

$$O = \frac{TE \times MPH)}{375} T,$$

where, O = horsepower-hours output.
TE = pounds tractive effort for the section.
MPH = miles per hour speed on the section, and
T = hours running time for the section

from the locomotive curve, similar to Fig. 5, the efficiency E_t, corresponding to the speed and tractive effort of (14) is read. Then the input to the locomotive for traction for the section is:

$$I_h = \frac{O}{E_t},$$

where, I_h = horsepower-hours input for traction.
The input in kilowatt-hours is:

$$I_k = 0.746\ I_h$$

(15) The input per section as found in (14) is for running only and does not include the energy required to bring the train from rest up to running speed. A safe allowance for this accelerating input may be made by finding from the curve, similar to Fig. 5, the rate of input which corresponds to the starting tractive effort and multiplying this by the sum of the times required for making all contemplated starts.

$$I_s = HP_s\ (T_{a'} + T_{a''} + T_{a'''} + \qquad)$$

I_s = horsepower-hours accelerating input,
HP_s = horsepower at starting tractive effort,
$T_{a'}$ $T_{a''}$ etc. = time for ecceleration for individual starts.

(16) When drifting, braking and standing (as well as when developing traction) the locomotive uses electrical energy for the operation of its auxiliaries. The average rate at which it is used during these periods may be found from the following:

$$HP_a = K(HP_c).$$

where, HP_a = average horsepower input to auxiliaries.
K = a constant.
HP_c = continuous horsepower capacity of the locomotive.

Values of K which may be used for each type of locomotive are:

Direct current	0.03
Single phase series	0.05
Motor-generator	0.09
Split phase	0.09

The total energy for auxiliaries during the drifting, braking and standing portion of the run is $I_a = HP_a\ (T_d + T_b + T_s)$

where, I_a = horsepower-hours for auxiliaries,
T_d = hours total drifting time,
T_b = hours total braking time,
and T_s = hours total standing time.

In kilowatt-hours this becomes:

$KWH_s = 0.746\ HP_s$.

(17) The total input to the locomotive for the run is the sum of the inputs for traction for all sections, as found in (14), the input for starting, as found in (15), and the input to the auxiliaries, as found in (16), that is:

$$I_H = (I_{h'} \times I_{h''} \times I_{h'''} + \quad) \quad + I_s + I_a.$$

and $I_K = 0.746\ I_H$,

where I_H = horsepower-hours total input,

$I_{h'}$, $I_{h''}$ etc. = horsepower-hours input for traction for individual sections,

I_K = kilowatt-hours total input.

(18) In studies of location as affected by electrification, the ability of the electric locomotive to hold the train on descending grades by regeneration (that is, by transforming the mechanical energy imparted to the train by such grades into electrical energy which is delivered to the distribution system for use in propelling other trains on the level or up grades) is an important factor where grades are long and steep. The amount of such regenerated energy which is delivered to the distribution system may be approximated closely by the methods already described for determining the energy required for propulsion.

Using the symbols of (2),

$$TE_G = 20\ G_D(W_D + W_C + T) - R_D W_D - R_T (T + W_C)$$

where, TE_G = lb. tractive effort available for regeneration,

and G_D = actual descending grade less curve;

also
$$I_G = \left[\frac{TE_G \times MPH_G}{375} \right] T_G$$

where I_G = horsepower-hours input to locomotive,

MPH_G = miles per hour at TE_G from curve, similar to Fig. 5,

and T_G = hours time down the grade at MPH_G;

also $O_G = I_G \times Ef$

where O_G = horsepower-hours locomotive output to the distribution system,

and Ef = Efficiency of the locomotive corresponding to MPH_G and TE_G.

In kilowatt-hours, the regenerated energy is:

$O_K = 0.746\ O_G$, and this must be deducted from the total input (I_K) to the locomotive for propulsion in order to find the net quantity of electrical energy required from the distribution system for the complete run.

(19) The methods and data outlined in this section for the selection of electric locomotives are approximate. However, the results obtained by their use will be sufficiently accurate for a preliminary determination regarding the probable economy of electrification. If such preliminary study indicates that electrification promises the best solution of the problem, a more accurate final study should be made by engineers specially trained in the application of electricity to traction.

Appendix B

(6) PREPARE IN FORM FOR CONVENIENT USE, ESSENTIAL OPERATING DATA REQUIRED FOR MAKING RELATIVE COMPARISONS OF VALUES FOR STUDIES OF LINE AND GRADE REVISIONS TO MEET MODERN OPERATING REQUIREMENTS

R. S. Marshall, Chairman, Sub-Committee; Hadley Baldwin, J. L. Campbell, A. W. Galbreath, W. L. R. Haines, C. P. Howard, A. K. Shurtleff, Walter Loring Webb.

This Committee has had published in the Manual of Recommended Practice of 1921, pages 800 to 817, inclusive, and in the supplements thereto, principles to be followed in the solution of railway location problems involving initial locations, as well as revision of lines that are being operated.

This matter has been discussed in considerable detail in the Proceedings of the Association.

The following is suggested as a short-cut method in obtaining and applying cost data in making studies of this character.

In order to determine the relative economic value of the line after the proposed improvements in alinement and grade have been constructed, compared with the operated line, it is necessary to determine the relative out-of-pocket operating cost. The savings in out-of-pocket operating costs, in relation to the cost of the proposed improvements chargeable to Additions and Betterments, will be the measure of the economic value of the improvements and this will largely depend on the volume of business to be handled and the physical characteristics of the operated line compared with the proposed revised line.

A practical formula for making relative comparisons of values for studies of line and grade revisions should include as large a portion of the direct expense of operating train service as possible. These expenses embrace Maintenance of Way, Maintenance of Equipment, and Transportation. The value of such a formula is greatly enhanced by the simplicity and ease with which it may be applied. Such a formula is now being used on some railroads to advantage; its application involves very little expense and train service costs are developed which enable reasonably accurate economic comparisons of handling traffic by various routes or by handling traffic over the proposed line and grades compared with the existing facilities that are being operated. In this formula the train hour is taken as the most appropriate unit of service and the principle is adopted that the cost per train hour, as herein defined, excluding wages, will vary in direct proportion to the tractive power of the locomotive used and the number of locomotives per train, or, more precisely, the ratio of locomotive miles to train miles.

It may be said that some of the elements of train service costs do not in fact vary in direct proportion to the train hours; that fuel and locomotive repairs per train hour, for example, will be greater if the train speed is 18 m.p.h. than if, under the same conditions as to grades and train loads, the train speed is 9 m.p.h., such difference in the train speed being due, in this case, to interference of other trains. It may be admitted that if, in the example cited, the average train speed should increase from 9 m.p.h. to 18 m.p.h. in consequence of a 50 per cent decrease in volume of traffic, the saving in fuel and locomotive repairs would probably be less than 50 per cent for the reason that the locomotives would be running instead of standing during 40 per cent (more or less) of the service time. The application of the formula here advocated would show a saving of 50 per cent in the example stated above because the train hours would decrease 50 per cent and the result, therefore, would be in error to the extent of the difference between 50 per cent and the amount of the actual decrease in these particular elements of cost. In practice, however, the comparisons do not usually involve such extreme fluctuations in train speed; on the contrary, the changes usually resulting from reconstruction of lines are in the train load and the factors affecting train speed tend to equalize each other.

Wherever extreme fluctuations in train speed enter into the problem special consideration should be given to the effect of such changes upon the unit cost per train hour. Sometimes it is feasible to do this by comparing unit costs on several existing lines with varying train speeds where all of the conditions are known, but in making such studies it is highly important to examine the method used in recording and distributing the basic cost data. They may not represent facts.

The unit cost per train hour embraces:

Wages of train and enginemen.
Fuel and water for locomotives.
Lubricants and other supplies for locomotives.
Enginehouse expenses.
Train supplies and expenses.

Locomotive repairs.
Locomotive depreciation and retirements.
Interest on locomotive investment.

In addition to the train hour cost as above defined, the formula provides for the inclusion, when applicable, of the following:

Maintenance of Way.
Equipment Rental—Per Diem.

These items represent approximately 80 per cent of the total maintenance and transportation expenses, which vary with the volume of traffic.

In the application of the formula for determining the relative out-of-pocket operating cost the following information is essential:

For the present line for a given period (usually an average winter and summer month.)

1. Distance between terminals—miles.
2. Ruling grade in each direction—length in miles and rate of grade.
3. Helper grade in each direction—length in miles and rate of grade.
4. Number of freight trains of each class in each direction, such as local, manifest and slow freight.
5. Wages of freight train and engine men in each class of service in each direction.
6. Wages of helper crews, in each direction.
7. Freight train miles for each class of service in each direction, excluding train switching miles.
8. Principal locomotive miles in each class of service in each direction, excluding train switching locomotive miles.
9. Helper locomotive miles, including the return light helper miles, in each direction.
10. Rating gross ton miles in each class of service in each direction.
11. Actual gross ton miles in each class of service in each direction.
12. Train hours in each class of service in each direction.
13. Train speed (miles per hour) between terminals in each class of service in each direction.
14. Average tractive power of locomotives in each class of freight service.
15. Annual Maintenance of Way expenses.

It is obviously necessary to separately consider those classes of freight service which, by reason of service requirements, will not be affected by the proposed changes in physical conditions or will not be affected to the same extent as other classes of service in which the train load and train speed is mainly dependent upon the physical characteristics of the road. The facts in each individual case must determine whether it is feasible to change the make-up of individual trains which may be operated on fixed schedules to handle particular classes of traffic subject to specific limitations of service.

For the line after the proposed improvements have been constructed it will be necessary to determine similar data covering the proposed operation for each of the above items for individual trips in each direction and for handling a given volume of business.

Among the many factors that affect the cost per train hour the most important are the size of the locomotive and the ratio of locomotive miles to train miles. Usually the same classes of locomotives will be used after the completion of the line and grade revision as are operated on existing facilities but in the event the proposed changes in the physical conditions permit the operation of a different size of motive power, the formula provides for adjustment of the train hour cost. If new locomotives be substituted for old, the formula gives effect to the interest upon the difference between the cost of the new locomotive and the depreciated value of the old one. The formula, however, does not and cannot make allowance for changes in type of locomotives used. If, in a given case, modern locomotives equipped with super-heaters, feed water heaters, boosters, or with tanks of greater capacity are to be substituted for older types not so equipped, that substitution presents a problem with which this Committee is not here concerned, but in such a case it would be necessary, in order to estimate the economic value of the proposed road improvements, to assume either:

(a) That the existing motive power will be used after the improvements are completed, or
(b) That the proposed new locomotives will be used on the existing line before the proposed road improvements are undertaken.

The latter assumption is the safest because it will ordinarily tend to reduce the savings which can be attributed to the proposed road improvement.

It is necessary to determine the actual cost per train hour on the particular district under consideration in order to compute the cost of handling a given volume of traffic with the existing facilities. This is accomplished by using the simple formula, (1) $C_t = C_h \times H$ in which:

C_t = Total cost of handling a given volume of traffic.
C_h = Cost per train hour.
H = Number of train hours.

This equation is used in developing the cost of train service on the existing line of railroad and compared with what the cost should be after the proposed improvements in line and grade have been constructed. In its application, a statement similar to the one below is necessary, which covers system data that is readily available, as it is the basis for further computations:

NORTH AND SOUTH RAILROAD

TABLE I—COST PER FREIGHT TRAIN HOUR

SYSTEM—YEAR 1927

System Data (For Freight Service Only):	*Total or Average*
1 Train Miles	14,311,135
2 Locomotive Miles	16,078,742
3 Train Hours	1,271,460
4 Average Tractive Power	68,272
5 Train Miles per Locomotive Miles (1/2)	.89

	Total Cost		*Cost per Train Hour*
6 Wages, train and enginemen (6/3)		$9,005,357	$ 7.08
7 Fuel	$3,528,609		
8 Water	365,489		
9 Lubricants	153,733		
10 Other Supplies	82,055		
11 Enginehouse Expenses	1,101,825		
12 Train Supplies and Expenses	1,110,346		
13 Locomotive Repairs	7,289,978		
14 Locomotive Depreciation	961,321		
15 Locomotive Retirements	20,253		
16 Interest on Locomotive Investment	1,833,084		
17 Total, excluding wages		$16,446,693	12.94
Total Cost per Train Hour			$20.02

Items 1 to 15 are of record usually in report to the Interstate Commerce Commission. Item 16 is computed by dividing 6 per cent of the depreciated value of locomotives owned in freight service by the number of train hours in freight service.

It should be remembered that the figures in Table I for a system include all classes of service and all the varying conditions that may exist on widely separated portions of a large system. It may be possible to obtain similar figures for particular divisions or districts where the conditions are comparable to those on the district where the improvements are proposed to be made. As hereinafter pointed out, accounting systems designed to show operating expenses for separate division or districts frequently embrace a considerable number of arbitrary allocations, but in individual cases it may be found that the allocation of the principal items of expense is sufficiently accurate to make it valuable as a check upon the unit cost developed by the formula. Such unit costs when available for separate divisions or districts should always be considered, but, on the contrary, they should never be used without careful analysis to determine whether or not they approximate the facts.

Table II shows similar information required in determining the cost of Yard Service.

NORTH AND SOUTH RAILROAD

TABLE II—COST PER YARD ENGINE HOUR

SYSTEM—YEAR 1927

	System Data (For Freight Service Only):			*Total or Average*
1	Yard Engine Hours			767,201
2	Cars Handled			11,508,015
3	Cars Handled per Engine Hour (2/1)			15.0
4	Average Tractive Power			47,357
		Total Cost		*Cost per Engine Hour*
5	Wages, train and enginemen (5/1)		$4,279,708	$ 5.58
6	Wages of other yard men (6/1)		1,450,010	1.89
7	Fuel	$ 574,991		
8	Water	59,125		
9	Lubricants	25,001		
10	Other Supplies	19,095		
11	Enginehouse Expenses	510,076		
12	Yard Supplies and Expenses	103,182		
13	Locomotive Repairs	1,644,421		
14	Locomotive Depreciation	249,616		
15	Locomotive Retirements	5,443		
16	Interest on Locomotive Investment	321,807		
17	Total, excluding wages		3,512,757	4.58
	Total Cost per Engine Hour			$12.05
	Average Cost per Car Handled 12.05/15.0			.803

NOTE.—Wages of other yard men include such as:

(a) Yard Masters and Clerks.
(b) Yard Switch and Signal Tenders.

The actual cost of wages on any particular district is readily obtained from the division operating records, which, divided by the number of train hours consumed in handling a given volume of traffic, results in the cost per train hour. Other items of cost used in ascertaining the determinable out-of-pocket cost of train service are not so easily obtained for the district as for the system, because of the fact that many of the accounts are pooled and the expenses by division or districts would necessarily be allocated on arbitrary bases. This equation recognizes the principle that train expenses, exclusive of wages, of engine and trainmen, will vary almost directly with the size or tractive effort of locomotives used. It is expressed as follows:

$$(2)\ C_d = C_s \times \frac{T\ P_d}{T\ P_s} \times \frac{L\ M_d}{T\ M_d} \times \frac{T\ M_s}{L\ M_s}$$

in which:

$L\ M_s$ = Locomotive miles, system.
$T\ M_s$ = Train miles, system.
$T\ P_s$ = Average tractive power of locomotives, system.
C_s = Cost per train hour of fuel, water, etc., system.
$L\ M_d$ = Locomotive miles, division.
$T\ M_d$ = Train miles, division.
$T\ P_d$ = Tractive effort of locomotives, division.
C_d = Cost per train hour of fuel, water, etc., division.

This equation results in properly equating the cost of such items as fuel, water, lubricants, other supplies for locomotives, enginehouse expenses, train supplies and expenses, locomotive repairs, depreciation, retirements and interest on locomotive investment to reflect the relative difference between the locomotive tractive effort miles per train mile on the division in question compared with the locomotive tractive effort miles per train mile on the system; in other words, it equates for the relative number of locomotive miles and difference in tractive effort of locomotives used in the trains on the district compared with the system.

Having ascertained the cost per train hour on the particular division the total cost of moving the traffic during the period being considered is determined by applying equation (1), i.e., by multiplying the cost per train hour by the total number of train hours.

To obtain a comparable figure for the line after the proposed revisions have been completed, it is then necessary to analyze the changed operating conditions in order to determine whether or not the average cost per train hour would be affected. If the train hour cost of the operated line includes the cost of helper service which is to be eliminated by the line and grade revisions, it will be convenient to determine the average train hour cost both with and without helper service, the latter figure to be applied after the completion of the improvements. Consideration should also be given to the effect of increased train load and distance in the average speed of trains. The average speed of trains may be increased with the completion of improvements by reason of the fact that increased train load will permit of decreasing the train density (less number of trains operated) and consequent less interference with a given volume of traffic to be handled. The effect of decreased interference on average speed between terminals, however, may be offset by increased distance and slowing up of the heavier freight train over the revised line. A detailed study should be made to determine the time between terminals on the lines to be compared. The Manual and Proceedings set forth a method of computing time between terminals, namely, the speed curve or graphic method.

If the time between terminals is materially changed it is proper to credit or debit the cost of car equipment. This is usually computed on the basis of per diem, which is designed to include car repairs, car depreciation and retirements, and interest on investment. In the example following, it is assumed that the increase in the average train speed between terminals on account of decrease in the number of trains operated will be offset by the slowing up of the heavier trains over longer ruling grades, the net result of which will be to permit the average time per train between terminals over the revised line to equal the time per train between terminals over the present line.

The Maintenance of Way expense data for the division should be collected by primary accounts covering a period of five years, if possible, in order to be able to analyze and ascertain, as far as practicable, how these expenses will be affected after the proposed line and grade revisions have been completed.

An example showing the application of the formula in which it is desired to know the cost of train service of moving a given volume of traffic between points "A" and "B" on the North and South Railroad, compared with the probable cost of moving the same traffic between the same points after certain line, grade and track revisions have been made, is worked out in Tables II to VII, inclusive. The engine district is single track with suitable passing sidings; it is 110 miles in length with a ruling grade northbound of .6 per cent and southbound of .4 per cent. There is a helper grade against northbound traffic of 1.2 per cent, which is 15 miles in length. This helper grade happens to be near the south end of the engine district, permitting helpers to be operated from the terminal at "A."

It is proposed to eliminate the helper grade by lowering the summit by a tunnel, and make other minor grade revisions which will reduce the ruling grade to .4 per cent northbound with no change in the southbound ruling grade. In addition to the proposed revisions in line and grade, extensions to certain passing sidings will be made, aggregating a total of two miles.

There is no material change in the distance between terminals. The estimated cost of the proposed improvements is $3,000,000.

These tables are self-explanatory and the results may be summarized as follows:

Annual operating cost, present line	$1,007,712
Annual operating cost, revised line	756,534
Annual saving	$ 251,178
Return on Investment	8.3%

From this low return on the investment it may be found desirable to defer the proposed improvements until such time as the traffic is increased to the capacity of the present facilities.

If the problem involves the cost of yard service, Table II is used in conjunction with division data, Table VIII, to compute the cost of engine service. The "car" is the most convenient unit to use in determining yard service and maintenance costs per unit of traffic. Maintenance of Way expenses per car will be determined by dividing the average cost for a given period by the number of cars handled through the yard in that period.

If yard improvements are proposed which will affect the operation, it is necessary to make a careful analysis to determine the effect on average yard service and maintenance of way costs. For example, it will be assumed that Capital expense of $50,000 in yard "A" to add two miles of yard tracks will permit an increase in the number of cars that can be handled per engine hour from 16 to 18; it will then require 1333⅓ instead of 1500 engine hours to handle 24,000 cars.

The return on the investment, as shown in Table IX, is 20.9 per cent.

NORTH AND SOUTH RAILROAD

TABLE III—COST OF FREIGHT TRAIN SERVICE BETWEEN "A" AND "B"

		Total or Average
	System Data (1927) from Table I:	
1	Cost per train hour, excluding wages	$12.94
2	Average tractive power of locomotives	68,272
3	Train miles per locomotive mile	.89

		North	*South*	*Total or Average*
	Division Data (Present Line—Through Freight, Jan. and June, 1928):			
4	Miles between terminals	110	110	......
5	Ruling grade, per cent	.60	.40	......
6	Helper grade, per cent, 15 miles	.120	......	......
7	Number of trains	364	360	724
8	Train miles	40,040	39,600	79,640
9	Principal locomotive miles	40,440	39,996	80,436
10	Helper locomotive miles (200 trains helped)	6,000*	......	6,000
11	Total locomotive miles	46,440	39,996	86,436
12	Train hours	2,860	2,475	5,335
13	Rating, gross ton miles (1000s)	120,681	210,870	331,551
14	Actual gross ton miles (1000s)	90,511	54,307	144,818
15	Wages, train and enginemen	$13,801	$12,400	$26,201
16	Wages, helper crews	$1,786	......	$1,786
17	Total wages	$15,587	$12,400	$27,987
18	Principal locomotive miles per train mile (9 ÷ 8)	......	......	1.01
19	Total locomotive miles per train mile (11 ÷ 8)	......	......	1.09
20	Train miles per train hour (8 ÷ 12)	14.0	16.0	14.9
21	Rating gross train load (13 ÷ 8)	3,014	5,325	4,163
22	Actual gross train load (14 ÷ 8)	2,261	1,371	1,818
23	Per cent of rating utilized (13 ÷ 14)	75.0	25.8	43.7
24	Average tractive power of locomotives	......	......	75,000

NOTE.—*Includes 3,000 light helper miles charged to northbound movement.

Factor:			
25	Including helper	75,000 ÷ 68,272 × .89 × 1.09	1.07
26	Excluding helper	75,000 ÷ 68,272 × .89 × 1.01	.99
Division Cost, Including Helper:			
27	Wages	$27,987 ÷ 5,335	$ 5.26
28	Fuel, water, etc.	1.07 ÷ $12.94	13.85
29	Total cost per train hour		$19.11
Division Cost, Excluding Helper:			
30	Wages	$26,201 ÷ 5,335	$ 4.91
31	Fuel, water, etc.	.99 ÷ $12.94	12.81
32	Total cost per train hour		$17.72
Train Service Expense of Handling Traffic Over Present Line:			
33	One year	$19.11 × 5,335 × 6	$611,712

TABLE IV—ESTIMATED TRAIN SERVICE COST—REVISED LINE

		North	*South*	*Total or Average*
Division Data (Revised Line—Through Freight):				
1	Miles between terminals	110	110	110
2	Ruling grade, per cent	.40	.40	.....
3	Helper grade, per cent	.....	.....	.....
4	Rating gross train load	5,325	5,325	.....
5	Per cent of rating utilized (23 Table III)	75.0	25.8	.....
6	Estimated actual gross train load (4 × 5)	3,994	.....	.....
7	Actual gross ton miles (14 Table III)	90,511	.....	.....
8	Number of trains (7 ÷ 6)	227	227	454
9	Train miles per train hour (20 Table III)	.....	.....	14.9
10	Train hours per trip (1 ÷ 9)	.....	.....	7.4
11	Total train hours, two months (8 × 10)	.....	.....	3,360
12	Cost per train hour (32 Table III)	.....	.....	$17.72
13	Average tractive power of locomotives (24 Table III)	.....	.....	75,000
Train Service Cost of Handling Traffic Over Revised Line:				
14	One year	$17.72 × 3,360 × 6		$357,234

TABLE V

Maintenance of Way Expenses, Present Line (5-year period):

		Actual	*Equated*	
1	Average per annum			$396,000
2	Miles of first main track	110 × 1	110	
3	Miles of passing sidings	20 × .5	10	
4	Equated track miles—present line		120	
5	Cost per equated track mile 396,000 ÷ 120			3,300

TABLE VI

Estimate Annual Maintenance of Way Expenses, Revised Line:

		Actual	Equated	
1	Miles of first main track	110 × 1	110	
2	Miles of passing sidings	22 × .5	11	
3	Equated track miles—revised line		121	
4	Annual cost per equated track mile (5 Table V)			$ 3,300
5	Total annual cost for revised line 121 × 3,300			399,300

TABLE VII

Total Cost of Handling Traffic Over Revised Line Compared with Present Line

	Present Line		
1	Train Service—33 Table III	$611,712	
2	Maintenance of Way—1 Table V	396,000	
	Total, Present Line		$1,007,712
	Revised Line		
3	Train Service—14 Table IV	$357,234	
4	Maintenance of Way—5 Table VI	399,300	
	Total, Revised Line		756,534
5	Annual Savings		$ 251,178
6	Return on Investment of $3,000,000		8.4%

TABLE VIII—COST OF YARD SERVICE YARD "A"

		Total or Average
	System Data (1927) from Table II:	
1	Cost per engine hour, excluding wages	$4.58
2	Average tractive power of locomotives	47,357
	Yard Data (Engine Service, Jan. and June, 1928):	
3	Cars handled	24,000
4	Engine hours worked	1,500
5	Wages, train and enginemen	$7,750
6	Wages, other yard men	3,000
7	Total wages	$10,750
8	Cars handled per engine hour (3 ÷ 4)	16.0
9	Average tractive power of locomotives	55,000
	Factor: 55,000 ÷ 47,357	1.16
	Yard Cost:	
10	Wages $10,750 ÷ 1,500	$ 7.17
11	Fuel, water, etc., 1.16 × $4.58	5.32
12	Total cost per engine hour	$12.49

		Total or Average
Yard Service Expense of Handling Traffic Through Yard "A"		
13	One year $12.49 × 1,500 × 6	$112,410
Maintenance of Way Cost:		
14	Maintenance of way per annum (average 5 years)	$5,760
15	Miles of yard track	5.7
16	Average cost per mile	$1,011

Table IX—Total Cost of Handling Traffic Through Proposed Improved Yard Compared with Present Yard

	Present Yard			
1	Engine service (from Table VIII)		$112,410	
2	Maintenance of way (from Table VIII)		5,760	
	Total, present yard			$118,170
	Proposed Improved Yard			
3	Total cars 6 × 24,000	144,000		
4	Cars handled per engine hour	18.0		
5	Engine hours	8,000		
6	Engine service $12.49 × 8,000		$99,920	
7	Maintenance of Way 7.7 miles × $1,011		7,785	
	Total, proposed improved yard			107,705
8	Saving per annum			$ 10,465
9	Return on Investment			20.9%

Attached is Exhibit A, which is a demonstration of the use in actual practice of the formula outlined in the foregoing report. The exhibit contains the computation of out-of-pocket cost of assembling and hauling coal from Kanawha and Eastern Kentucky District to Newport News, Virginia, and Exhibit B, which is copied from an Exhibit in Financial Docket No. 4818, submitted by the Chesapeake & Ohio Railway in a hearing before the Interstate Commerce Commission. This exhibit is a comparison of the out-of-pocket cost of existing routes with the estimated out-of-pocket cost over a proposed route in which it is assumed that the motive power will be used over both routes and the train hour cost is, therefore, uniform throughout. This exhibit also contains train hour cost by divisions as well as the system as a whole.

Exhibit A

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

OUT-OF-POCKET COST OF HAULING KANAWHA AND EASTERN KENTUCKY DISTRICTS COAL TO TIDEWATER

BASED ON JANUARY AND JUNE, 1926

SUMMARY

	Coal River Field (a)		Logan Field (b)		Big Sandy Field (c)	
	Cost Per Car	Cost per Net Ton (d)	Cost Per Car	Cost per Net Ton (d)	Cost Per Car	Cost per Net Ton (d)
Mine run train service	$ 3.11	$ .0571	$ 2.77	$ .0508	$ 2.63	$ .0483
Road train service	23.69	.4347	25.84	.4741	30.80	.5651
Yard switching service	8.13	.1492	8.28	.1519	9.87	.1811
Maintenance of way	6.53	.1198	7.17	.1316	9.58	.1758
Tidewater agency	16	.0029	.16	.0029	.16	.0029
Joint facilities	--------	--------	--------	--------	--------	--------
Equipment Rental	16.32	.2994	16.86	.3094	18.08	.3317
Total	$57.94	$1.0631	$61.08	$1.1207	$71.12	$1.3049
Average per net ton Eastern Kentucky District					--------	$1.3020
Average per net ton Kanawha District, based on tonnage loaded East in 1926					--------	1.0925

Note.—(a) Includes that portion of Kanawha District, St. Albans and East.
(b) Includes that portion of Kanawha District west of St. Albans.
(c) Includes that portion of Eastern Kentucky District known as Kentucky No. 5 Field.
(d) Based on 54.50 net tons per car.

COST OF MINE RUN SERVICE

COAL RIVER FIELD—ASSEMBLY

(DETAILS OMITTED)

COST OF MINE RUN SERVICE

LOGAN FIELD—ASSEMBLY (PEACH CREEK)

	January 1926	June 1926	Total or Average
Number of trains	604	572	1,176
Number of train miles	19,298	17,732	37,030
Number of locomotive miles	25,846	23,562	49,408
Type of locomotive used—Various—Average tractive effort			48,142
Crew Time—Terminal Hours	1,788	1,545	3,333
Road Hours	5,106	3,920	9,026
Total Hours	6,894	5,465	12,359
Loaded cars assembled	29,547	31,311	60,858
Wages, train and enginemen	$40,295	$30,108	$70,403

		Total Cost	Cost per Train Hour
Locomotive repairs	.9800 × $6.1433	$54,340	$6.0204
Locomotive depreciation	.9800 × .5775	5,199	.5760
Wages		70,403	7.8000
Fuel	.9800 × 2.6093	23,080	2.5571
Water	.9800 × .2611	2,310	.2559
Lubricants	.9800 × .0901	797	.0883
Other supplies	.9800 × .0733	648	.0718
Enginehouse expenses	.9800 × .7039	6,226	.6898
Train supplies and expenses	.9800 × .6381	5,644	.6253
Total		$168,647	$18.6846
Cost per loaded car			$ 2.7712

COST OF FREIGHT TRAIN SERVICE

LOGAN FIELD ASSEMBLY (PEACH CREEK)—HANDLEY

	January and June 1926 East	January and June 1926 West	Total or Average
Number of trains	204	62	265
Number of train miles	26,500	7,950	34,450
Number of locomotive miles			40,056
Gross Ton Miles (Thou)	134,742	13,563	148,305
Type of locomotive used—Mallet—Average tractive effort			73,300
Crew Time—Terminal Hours	291	59	350
Road Hours	2,749	639	3,388
Total Hours	3,040	698	3,738
Gross train load	5,085	1,706	4,305
Train miles per train hour	9.64	12.44	10.17
Wages, train and enginemen			$18,798

		Total Cost	Cost per Train Hour
Locomotive repairs	1.2997 × $6.1433	$27,050	$7.9844
Locomotive depreciation	1.2997 × .5775	2,543	.7506
Wages		18,798	5.5484
Fuel	1.2997 × 2.6093	11,490	3.3913
Water	1.2997 × .2611	1,150	.3394
Lubricants	1.2997 × .0901	397	.1171
Other supplies	1.2997 × .0733	323	.0593
Enginehouse expenses	1.2997 × .7039	3,100	.9149
Train supplies and expenses		3,298	.9734
Total		$68,149	$20.1148

COST OF FREIGHT TRAIN SERVICE

KANAWHA AND EASTERN KENTUCKY DISTRICTS COAL

JANUARY AND JUNE 1926

	Miles	Speed	Gross Train Load	Cars Per Train (b)	No. of Train or Helper Hours	Cost Per Train or Helper Hour	Total Cost	Cost Per Car
Coal River Field.								
Eastbound								
Assembly-Handley	48.1(a)	7.08	4,896	65.5	6.79	$17.1488	$116.44	$1.7777
Handley-Newport News							825.89	12.0522
Total							942.33	13.8299
Westbound								
Newport News-Handley							630.76	7.3428
Handley-Assembly	48.1(a)	6.01	1,102	54.4	8.00	17.1488	137.19	2.5219
Total							767.95	9.8647
Total Round Trip							1,710.28	23.6946
Logan Field.								
Eastbound								
Assembly-Handley	129.0	9.64	5,085	68.0	13.38	20.1148	269.14	3.9579
Handley-Newport News							825.89	12.0522
Total							1,095.03	16.0101
Westbound								
Newport News-Handley							630.76	7.3428
Handley-Assembly	129.0	12.44	1,706	84.0	10.37	20.1148	208.59	2.4832
Total							839.35	9.8260
Total Round Trip							1,934.38	25.8361

Big Sandy Field.								
Eastbound								
Assembly-Russell	110.1	9.04	4,785	64.0	12.18	18.0580	219.95	$ 3.4367
Russell-Handley	94.3	8.63	3,959	52.9	10.93	17.5475	191.79	3.6255
Handley-Newport News							825.89	12.0522
Total							1,237.63	19.1144
Westbound								
Newport News-Handley							630.76	7.3428
Handley-Russell	94.3	8.52	2,972	110.0	11.07	17.5475	194.25	1.7659
Russell-Assembly	110.1	10.54	1,483	73.2	10.45	18.0580	188.71	2.5780
Total							1,013.72	11.6867
Total Round Trip							2,251.35	30.8011
Common.								
Eastbound								
Handley-Hinton	72.5	8.10	3,591	48.0	8.95	18.1021	162.01	3.3752
Hinton-Clifton Forge	79.9	9.92	4,496	60.1	8.05	19.5374	157.28	2.6170
Helper			4,496	60.1	5.42	12.4576	67.52	1.1235
Clifton Forge-Gladstone	111.5	11.95	6,854	91.7	9.33	16.6956	155.77	1.6987
Gladstone-Fulton	120.7	14.04	6,701	89.6	8.60	16.8870	145.23	1.6209
Fulton-Newport News	73.1	15.41	6,386	85.4	4.74	20.6542	97.90	1.1464
Helper			6,386	85.4	3.26	12.3266	40.18	.4705
Total							825.89	12.0522
Westbound								
Newport News-Fulton	73.1	22.76	2,126	104.9	3.21	20.6542	66.30	.6320
Fulton-Gladstone	120.7	12.25	2,223	109.7	9.85	16.8870	166.34	1.5163
Gladstone-Clifton Forge	111.5	11.26	2,001	98.7	9.90	16.6956	165.29	1.6747
Clifton Forge-Hinton	79.9	13.71	1,234	60.9	5.83	19.5374	113.90	1.8703
Hinton-Handley	72.5	11.04	1,461	72.1	6.57	18.1021	118.93	1.6495
Total							630.76	7.3428
Total Round Trip							1,456.65	19.3950

Note.—(a) Weighted distance based on tonnage loaded east from Coal River and Old Kanawha Fields, 1926.
(b) Based on 74.77 gross tons per car, loaded; and 20.27 gross tons per car, empty.

COST OF FREIGHT TRAIN SERVICE

HANDLEY—HINTON

	January and June 1926 East	January and June 1926 West	Total or Average
Number of trains			2,280
Number of train miles	61,751	69,722	131,473
Number of locomotive miles			135,444
Gross ton miles (Thou)	221,738	101,836	323,574
Type of locomotive used—Mallet—Average tractive effort			74;200
Crew Time—Terminal Hours	677	1,288	1,965
Road Hours	7,628	6,314	13,942
Total Hours	8,305	7,602	15,907
Gross train load	3,591	1,461	2,461
Train Miles per train hour	8.10	11.04	9.43
Wages, train and enginemen			$74,124

		Total Cost	Cost per Train Hour
Locomotive repairs	1.1657 × $6.1433	$99,841	$7.1612
Locomotive depreciation	1.1657 × .5775	9,386	.6732
Wages		74,124	5.3166
Fuel	1.1657 × 2.6093	42,407	3.0417
Water	1.1657 × .2611	4,244	.3044
Lubricants	1.1657 × .0901	1,464	.1050
Other supplies	1.1657 × .0733	1,191	.0854
Enginehouse expenses	1.1657 × .7039	11,439	.8205
Train supplies and expenses		8,283	.5941
Total		$252,379	$18.1021

COST OF FREIGHT TRAIN SERVICE

HINTON—CLIFTON FORGE

	January and June 1926		Total or Average
	East	West	
Number of trains			2,334
Number of train miles	71,742	73,394	145,136
Number of locomotive miles			155,835
Gross ton miles (Thou)	322,560	89,817	412,377
Type of locomotive used—Mallet—Average tractive effort			77,910
Crew Time—Terminal Hours	920	435	1,355
Road Hours	7,225	5,355	12,580
Total Hours	8,145	5,790	13,935
Gross train load	4,496	1,234	2,841
Train miles per train hour	9.92	13.71	11.54
Wages, train and enginemen			$67,935.

		Total Cost	Cost per Train Hour
Locomotive repairs	1.2757 × $6.1433	$98,739	$ 7.8489
Locomotive depreciation	1.2757 × .5775	9,268	.7367
Wages		67,935	5.4002
Fuel	1.2757 × 2.6093	41,875	3.3287
Water	1.2757 × .2611	4,190	.3331
Lubricants	1.2757 × .0901	1,445	.1149
Other supplies	1.2757 × .0733	1,176	.0935
Enginehouse expenses	1.2757 × .7039	11,297	.8980
Train supplies and expenses		9,855	.7834
Total		$245.780	$19.5374

COST OF HELPER SERVICE

HINTON—CLIFTON FORGE

	January 1926	June 1926	Total or Average
Number of trains helped	325	323	648
Number of helper hours	1,907	1,602	3,509
Helper hours per train	5.87	4.96	5.42
Type of locomotive used—Mallet—Average tractive effort			75,650
Wages, helper crews	$4,082	$3,444	$7,526

		Total Cost	Cost per Helper Hour
Locomotive repairs	1.1537 × $6.1433	$24,870	$7.0875
Locomotive depreciation	1.1537 × .5775	2,338	.6663
Wages		7,526	2.1448
Fuel	20 tons per day @ $1.70÷24	4,971	1.4167
Water	10% of fuel cost	497	.1417
Lubricants	1.1537 × .0901	365	.1039
Other supplies	1.1537 × .0733	297	.0846
Enginehouse expenses	1.1537 × .7039	2,850	.8121
Total		$43,714	$12.4576

COST OF FREIGHT TRAIN SERVICE

CLIFTON FORGE—GLADSTONE

	January and June 1926		Total or Average
	East	West	
Number of trains			987
Number of train miles	55,327	55,182	110,509
Number of locomotive miles			111,580
Gross ton miles (Thou)	379,209	110,429	489,638
Type of locomotive used—Mikado—Average tractive effort			70,881
Crew Time—Terminal Hours	281	274	555
Road Hours	4,628	4,899	9,527
Total Hours	4,909	5,173	10,082
Gross train load	6,854	2,001	4,431
Train miles per train hour	11.95	11.26	11.59
Wages, train and enginemen			$43,679
		Total Cost	Cost per Train Hour
Locomotive repairs	1.0914 × $6.1433	$63,877	$6.7048
Locomotive depreciation	1.0914 × .5775	6,005	.6303
Wages		43,679	4.5848
Fuel	1.0914 × 2.6093	27,131	2.8478
Water	1.0914 × .2611	2,715	.2850
Lubricants	1.0914 × .0901	937	.0983
Other supplies	1.0914 × .0733	762	.0800
Enginehouse expenses	1.0914 × .7039	7,318	.7682
Train supplies and expenses	1.0914 × .6381	6,635	.6964
Total		$159,059	$16.6956

COST OF FREIGHT TRAIN SERVICE
GLADSTONE—FULTON
(DETAILS OMITTED)

COST OF FREIGHT TRAIN SERVICE
FULTON—NEWPORT NEWS
(DETAILS OMITTED)

COST OF HELPER SERVICE
FULTON—NEWPORT NEWS
(DETAILS OMITTED)

COST OF YARD SERVICE

KANAWHA AND EASTERN KENTUCKY DISTRICTS COAL

JANUARY AND JUNE, 1926

YARD	No. of Cars One Way	Switching Cost	Other Yard Cost	Total Yard Cost	Cost per per Car One Way	Cost per Car Round Rip
Coal River Field.						
Assembly	173,419	$ .4440	$ .0269	$ .4709	$ .4709	$ .9418
Handley	--------	--------	--------	.3833(a)	.2502	.5004
Other	515,698	3.1897	.1526	3.3423	3.3423	6.6846
Total					$4.0634	$8.1268
Logan Field.						
Assembly	127,170	$ .3921	$ .0225	$ .4146	$ .4146	$ .8292
Handley	96,142	.3596	.0237	.3833	.3833	.7666
Other	515,698	3.1897	.1526	3.3423	3.3423	6.6846
Total					$4.1402	$8.2804
Big Sandy Field.						
Assembly	101,165	$ .4131	$ .0252	$ .4383	$ .4383	$ .8766
Russell	285,806	.7400	.0335	.7735	.7735	1.5470
Handley	96,142	.3596	.0237	.3833	.3833	.7666
Other	515,698	3.1897	.1526	3.3423	3.3423	6.6846
Total					$4.9374	$9.8748
Other Yards.						
Hinton	129,826	$ .3472	$ .0210	$ .3682	$ .3682	$ .7364
Clifton Forge	130,737	.4835	.0336	.5171	.5171	1.0342
Gladstone	105,034	.1376	.0185	.1561	.1561	.3122
Fulton	104,453	.4011	.0275	.4286	.4286	.8572
Newport News	45,648	1.8203	.0520	1.8723	1.8723	3.7446
Total					$3.3423	$6.6846

Note.—(a) Weighted average based on the present (65.28%) of the coal loaded east from the Coal River Field to the total loaded in Kanawha District, St. Albans and east.

COST OF YARD SERVICE

ASSEMBLY POINT IN LOGAN FIELD

PEACH CREEK

		January 1926	June 1926	Total or Average
Total cars handled		65,030	62,140	127,170
Engine hours worked		3,493	2,257	5,750
Cars handled per engine hour		18.62	27.53	22.12
Type of locomotive used—Various—Average tractive effort				53,505
Wages, train and enginemen		$13,000	$8,799	$21,799
		Total Cost	Cost Per Eng. Hour	Cost Per Car
Locomotive repairs	1.2089 × $2.1032	$14,620	$2.5426	
Locmotive depreciation	1.2089 × .3030	2,106	.366[illegible]	
Wages, train and enginemen		21,799	3.79[illegible]	
Fuel	1.2089 × .8556	5,947	1.0343	
Water	1.2089 × .0880	612	.1064	
Lubricants	1.2089 × .0274	190	.0331	
Other supplies	1.2089 × .0389	270	.0470	
Enginehouse expenses	1.2089 × .6217	4,322	.7516	
Total		$49,866	$8.6724	$.3921
Yard supplies and expenses		712	.1238	.0056
Yardmasters and clerks	25% of $8,575	2,144	.3729	.0169
Yard switch and signal tenders		-------	------	------
Total		2,856	.4967	.0225
Grand Total		$52,722	$9.1691	$.4146
Total cost per car, one way				.4146
Total cost per car, round trip				.8292

COST OF YARD SERVICE

CLIFTON FORGE YARD

		January 1926	June 1926	Total or Average
Total cars handled		63,468	66,269	130,737
Engine hours worked		3,258	2,592	5,850
Cars handled per engine hour		19.48	25.6	22.35
Type of locomotive used—Various—Average tractive effort				51,996
Wages, train and enginemen		$18,973	$16,492	$35,465
		Total Cost	Cost per Eng. Hour	Cost per Car
Locomotive repairs	1.1748 × $2.1032	$14,454	$ 2.4708	
Locomotive depreciation	1.1748 × .3030	2,083	.3560	
Wages		35,465	6.0624	
Fuel	1.1748 × .8556	5,880	1.0052	
Water	1.1748 × 0880	605	1034	
Lubricants	1.1748 × .0274	188	0322	
Other supplies	1.1748 × 0389	267	0457	
Enginehouse expenses	1.1748 × 6217	4,274	7304	
Total		$63,216	$10 8061	4835
Yard supplies and expenses		732	1251	0056
Yardmasters and clerks	25% of $10,284	2,571	4395	0197
Yard switch and signal tenders	25% of 4,361	1,090	1863	0083
Total		4,393	$ 7509	0336
Grand Total		$67,609		$ 5171
Total cost per car, one way				5171
Total cost per car, round trip				1 0342

COST OF YARD SERVICE

GLADSTONE

		January 1926	June 1926	Total or Average
Total cars handled		50,511	54,523	105,034
Engine hours worked		824	720	1,544
Cars handled per engine hour		61 30	75.70	68 03
Type of locomotive used—Various—Average tractive effort				59,894
Wages, train and enginemen		$3,211	$2,811	$6,022
		Total Cost	Cost per Eng. Hour	Cost per Car
Locomotive repairs	1.3533 × $2.1032	$4,395	$2 8463	
Locomotive depreciation	1.3533 × .3030	633	.4100	
Wages		6,022	3.9003	
Fuel	1.3533 × .8556	1,788	1.1579	
Water	1.3533 × .0880	184	.1191	
Lubricants	1.3533 × .0274	57	.0371	
Other supplies	1.3533 × .0389	81	.0526	
Enginehouse expenses	1.3533 × .6217	1,299	.8413	
Total		$14,459	$9.3646	$.1376
Yard supplies and expenses		588	.3808	.0056
Yardmasters and clerks	25% of $3,036	759	.4916	.0072
Yard switch and signal tenders	25% of 2,385	596	.3860	.0057
Total		1,943	1.2584	.0185
Grand Total		$16,402	$10.6230	$.1561
Total cost per car, one way				.1561
Total cost per car, round trip				.3122

COST OF YARD SERVICE

NEWPORT NEWS

		January 1926	June 1926	Total or Average
Total cars handled		19,597	26,051	45,648
Engine hours worked		4,591	4,840	9,431
Cars handled per engine hour		4.3	5.4	4.8
Type of locomotive used—Various—Average tractive effort				46,763
Wages, train and enginemen		$20,629	$22,229	$42,858
		Total Cost	Cost Per Eng. Hour	Cost Per Car
Locomotive repairs	1.0566 × $2.1032	$20,958	$2.2222	
Locomotive depreciation	1.0566 × .3030	3,019	.3201	
Wages		42,858	4.5444	
Fuel	1.0566 × .8556	8,527	.9040	
Water	1.0566 × .0880	877	.0930	
Lubricants	1.0566 × .0274	273	.0290	
Other supplies	1.0566 × .0389	388	.0411	
Enginehouse expenses	1.0566 × .6217	6,195	.6569	
Total		$83,095	$8.8107	$1.8203
Yard supplies and expenses		256	.0271	.0056
Yardmasters and clerks	25% of $8,462	2,116	.2244	.0464
Yard switch and signal tenders		--------	--------	--------
Total		2,372	.2515	.0520
Grand Total		$85,467	$9.0622	$1.8723
Total cost per car, one way				1.8723
Total cost per car, round trip				3.7446

MAINTENANCE OF WAY EXPENSES

COAL RIVER, LOGAN AND BIG SANDY FIELDS COAL TO NEWPORT NEWS

BASED ON OPERATIONS IN 1925

	Miles One Way	Gross Tons Per Car			Cost Per	
		Loaded (a)	Empty (b)	Total	1000 G. T. M.	Car
Coal River Field.						
Branch Lines	15.0	1,121.5	304.1	1,425.6	$1.60430	$2.2871
Assembly—Handley	49.6(d)	3,708.6	1,005.4	4,714.0	.34084	1.6067
Handley—Newport News						15.1407
Total						19.0345
Portion of M. of W. Expenses that vary with business (c)					.3433	6.5345
Logan Field.						
Branch Lines	12.9	964.5	261.5	1,226.0	1.24770	1.5297
Peach Creek—Barboursville	63.9	4,777.8	1,295.3	6,073.1	.20505	1.2453
Barboursville—Handley	65.1	4,867.5	1,319.6	6,187.1	.34084	2.1088
Handley—Newport News						15.1407
Total						20.0245
Portion of M. of W. Expenses that vary with business (c)					.3580	7.1688
Big Sandy Field.						
Branch Lines	13.9	1,039.3	281.3	6,187.1	.49097	3.0377
Assembly—Russell	110.1	8,232.2	2,231.7	10,463.9	.49097	5.1375
Russell—Handley	94.3	7,050.9	1,911.5	8,962.4	.34084	3.0547
Handley—Newport News						15.1407
Total						26.3706
Portion of M. of W. Expenses that vary with business (c)					.3632	9.5778
Common.						
Handley—Hinton	72.5	5,420.8	1,496.6	6,890.4	.32286	2.2246
Hinton—Clifton Forge	79.9	5,974.1	1,619.6	7,593.7	.33720	2.5606
Clifton Forge—Gladstone	111.5	8,336.9	2,260.1	10,597.0	.22590	2.3939
Gladstone—Fulton	120.7	9,024.7	2,446.6	11,471.3	.28485	3.2676
Fulton—Newport News	73.1	5,465.7	1,481.7	6,947.4	.50947	3.5395
Newport News Terminal						1.1545
Total						$15.1407

Note.—(a) Based on average carload of coal loaded (54.50 tons) in 1925
(b) " " " weight of empty car 20.27 "
(c) " " formula published in AREA Manual of 1921, Supplement Volume No. 27, Bulletin No. 278, August 1925.
(d) Weighted distance based on tonnage loaded from that portion of Kanawha District, St. Albans and east.

MAINTENANCE OF WAY AND STRUCTURES EXPENSE PER 1000 G. T. M.

DIVISION	M. of W. & S. Expense Freight	1000 G. T. M. Freight	Cost Per 1000 G. T. M.
HUNTINGTON			
Main Line	$1,383,392	4,058,769	$ .34084
Branch Lines	1,167,076	727,467	1.60430
LOGAN			
Main Line	446,528	2,177,682	.20505
Branch Lines	493,422	395,465	1.24770
BIG SANDY			
Main and Branch Lines	1,170,180	2,383,407	.49097
HINTON			
Main Line	650,373	2,014,392	32286
CLIFTON FORGE			
Alleghany	814,812	2,416,374	.33720
James River	681,256	3,015,695	.22590
RICHMOND			
Rivanna	815,230	2,861,940	.28485
Peninsula	671,200	1,317,453	.50947
		Number of Cars	Cost Per Car
NEWPORT NEWS AND NORFOLK TERMINAL			
Newport News—Norfolk	267,465	231,678	$1.15450

PERCENT OF TOTAL MAINTENANCE OF WAY AND STRUCTURES AND MAINTENANCE OF EQUIPMENT (PLANT MAINTENANCE) EXPENSES AFFECTED BY USE—PERIOD 1925

COAL RIVER AND KANAWHA FIELDS TO NEWPORT NEWS

I C C No.		Total	Percent of total M. of W. & S. and M. of E.	Percent affected by use	Percent of total M. of W. & S. and M. of E. affected by use
	Maintenance of Way and Structures.				
201	Superintendence	$ 413,594	4.63	20	.93
212	Ties	910,986	10.20	30	3.06
214	Rails	525,126	5.88	100	5.88
218	Ballast	399,073	4.47	80	3.58
202	Roadway maintenance	1,183,409	13.25		
216	Other track material	441,634	4.95	100	4.95
220	Track laying and surfacing	1,650,723	18.49	55	10.17
221	Right-of-way fences	17,685	.20		
225	Crossings and signs	89,878	1.01		
269	Roadway machines	45,835	.51		
271	Small tools and supplies	88,783	.99	40	.40
272	Removing snow, ice and sand	15,732	.18		
206	Tunnels and subways	777,437	8.71	10	.87
208	Bridges, trestles and culverts	406,912	4.56	10	.46
227	Station and office buildings	163,441	1.83		
229	Roadway buildings	51,159	.57		
231	Water stations	148,374	1.66	10	.17
233	Fuel stations	48,089	.54	15	.08
235	Shops and engine houses	316,409	3.54	10	.35
237	Grain elevators	1,742	.02		
239	Storage warehouses	923	.01		
241	Wharves and docks	199,779	2.24	10	.22
243	Coal and ore wharves	75,721	.85	10	.08
253	Power plant buildings	24,971	.28		
255	Power sub-station buildings	1,041	.01		
247	Telegraph and telephone lines	60,333	.68		
249	Signals and interlockers	283,922	3.18	30	.95
267	Paving	748	.01		
273	Assessments for public improvements	801	.01		
274	Injuries to persons	29,366	.33	50	.17
275	Insurance	63,533	.71		
276	Stationery and printing	11,872	.13	10	.01
277	Other expenses	428			
	Sub-Total M. of W. and S.	$8,449,459			

	Maintenence of Equipment				
302	Shop machinery	$ 443,018	4.96	40	1.98
304	Power plant machinery	36,067	.41	5	.02
	Sub-Total M. of E.	$ 479,085			
	Sub-Total M. of W. & S. and M. of E.	$8,928,544	100.00		34.33
278	Maintaining joint tracks, yards and other facilities—Dr.	$ 110,609			
279	Maintaining joint tracks, yards and other facilities—Cr.	5,714			
	Net debit or credit	104,895			
	TOTAL—FREIGHT	$9,033,439			

TIDEWATER COAL AGENCY EXPENSE

NEWPORT NEWS

JANUARY AND JUNE, 1926

	January	June	Total
Portion of agency expense	$1,398	$1,574	$2,972
Coal agency	845	868	1,713
Total	$2,243	$2,442	$4,685
Coal dumped (cars)	9,829	18,890	28,719
Average cost per car	$.2282	$.1293	$.1631

CAR DETENTION

JANUARY AND JUNE, 1926

		Loaded	Left Over	Total Delay Round Trip
At Mines.				
Big Sandy	January	18,986	27,104	
	June	19,336	21,766	
	Total	38,322	48,870	1.2752
Logan	January	32,571	43,051	
	June	35,816	44,222	
	Total	68,387	87,273	1.2762
Coal River	January	23,527	24,153	
	June	24,285	26,470	
	Total	47,812	50,623	1.0588

		Loads Forwarded	Loads Left Over	Average Daily Delay	Empties Forwarded	Empties Left Over	Average Daily Delay	Total Delay Round Trip
In Assembly Yards.								
Big Sandy	January	18,882	9,845	....	17,810	6,356	....	....
	June	19,890	6,550	....	16,978	5,120	....	....
	Total	38,772	16,395	.4229	34,788	11,476	.3299	.7528
Logan (Peach Creek)	January	31,171	16,240	....	30,451	7,081	....	....
	June	31,085	16,030	....	31,118	11,641	....	....
	Total	62,256	32,270	.5183	61,575	18,722	.3041	.8224
Coal River	January	14,517	7,270	....	11,245	10,232	....	....
	June	11,078	2,126	....	13,158	8,529	....	....
	Total	25,595	8,396	.3280	24,403	18,761	.7688	1.0968
In Intermediate Yard.								
Russell	January	56,928	23,698	....	56,405	16,399	....	....
	June	65,111	27,595	....	62,359	7,801	....	....
	Total	122,039	51,293	.4203	118,764	24,200	.2038	.6241
Handley	January	13,377	4,810	....	6,933	1,477	....	....
	June	14,752	2,603	....	5,660	679	....	....
	Total	28,129	7,413	.2635	12,593	2,156	.1712	.4347

Hinton	January,	26,142	6,193	....	23,055	2,350	....	....
	June	25,356	2,504	....	23,473	2,203	....	....
	Total	51,498	8,697	.1689	46,528	4,553	.0979	.2668
Clifton Forge	January	24,005	12,012	....	21,252	4,189	....	....
	June	23,493	8,249	....	22,479	5,389	....	....
	Total	47,498	20,261	.4266	43,731	9,578	.2190	.6456
Gladstone	January	21,339	6,150	....	19,221	2,383	....	....
	June	22,086	5,434	....	21,702	1,585	....	....
	Total	43,425	11,584	.2668	40,923	3,968	.0970	.3638
Fulton	January	11,499	1,867	....	16,159	2,333	....	....
	June	18,095	2,096	....	20,384	2,710	....	....
	Total	29,594	3,963	.1339	36,543	5,043	.1380	.2719
		Cars Dumped at Dock	Cars on Hand					
Newport News	January	9,829	66,759	....	11,477	3,293	....	....
	June	17,224	103,212	....	17,546	3,379	....	....
	Total	27,053	169,971	6.2829	28,993	6,672	.2301	6.5130

IN FREIGHT TRAINS	Number of Trains	Crew Hours	Crew Hours Per Train		
Mines—Big Sandy Assembly	975	7,969	8.17	.3404	.6808
Mines—Logan Assembly	1,176	12,359	10.51	.4379	.8658
Mines—Coal River Assembly	1,461	15,330	10.49	.4371	.8742
Big Sandy Assembly—Russell	1,005	12,356	12.29	.5121	1.0202
Russell—Handley	232	2,802	12.08	.5033	1.0066
Peach Creek—Handley	265	3,738	14.11	.5879	1.1758
Coal River—Handley	95	1,253	13.19	.5496	1.0992
Handley—Hinton	2,280	15,907	6.98	.2908	.5816
Hinton—Clifton Forge	2,334	13,935	5.97	.2487	.4974
Clifton Forge—Gladstone	987	10,082	10.21	.4254	.8508
Gladstone—Fulton	817	7,975	9.76	.4067	.8134
Fulton—Newport News	670	3,383	5.05	.2104	.4208

COST OF EQUIPMENT RENTAL (PER DIEM)

COAL RIVER, LOGAN AND BIG SANDY FIELDS COAL

JANUARY AND JUNE, 1926

	Coal River (Days)	Logan (Days)	Big Sandy (Days)
At mines	1.0588	1.2762	1.2752
In mine run trains	.8742	.8658	.6808
In assembly yards	1.0968	.8224	.7528
In Intermediate Yards.			
Russell			.6241
Handley	.2838(b)	.4347	.4347
Hinton	.2668	.2668	.2668
Clifton Forge	.6456	.6456	.6456
Gladstone	.3638	.3638	.3638
Fulton	.2719	.2719	.2719
In Newport News and Dock Yard	6.5130	6.5130	6.5130
In Freight Trains.			
Assembly-Russell			1.0202
Russell-Handley			1.0066
Coal River-Handley	.7176(b)		
Peach Creek-Handley		1.1758	
Handley-Hinton	.5816	.5816	.5816
Hinton-Clifton Forge	.4974	.4974	.4974
Clifton Forge-Gladstone	.8508	.8508	.8508
Gladstone-Fulton	.8134	.8134	.8134
Fulton-Newport News	.4208	.4208	.4208
Total	15.2563	15.8000	17.0195
Factor (a)	1.0596	1.0596	1.0596
Grand total	16.3159	16.8596	18.0791

Note.—(a) Ratio of total cars on line including bad order to total cars on line, excluding bad order.
(b) Weighted average based on the percent (65.28%) of the coal loaded east from the Coal River Field to the total loaded in Kanawha District, St. Albans and east.

FREIGHT TRAIN EXPENSES PER TRAIN HOUR

YEAR 1925

	Total Cost	Cost Per Train Hour
Enginemen	$4,186,264	$3.0104
Fuel	3,628,551	2.6093
Water	363,031	.2611
Lubricants	125,306	.0901
Other supplies	101,973	.0733
Enginehouse expenses	978,953	.7039
Trainmen	4,597,777	3.3063
Train supplies and expenses	887,329	.6381
Total	$14,869,188	$10.6925
Locomotive repairs	8,543,003	6.1433
Locomotive depreciation	803,090	.5775
Total	$9,346,093	$6.7208
Grand Total	$24,215,281	$17.4133
Train miles		14,097,575
Locomotive miles		15,323,066
Train hours		1,390,615
Average tractive power, freight locomotives—Lbs		60,329

YARD SERVICE EXPENSES PER ENGINE HOUR

YEAR 1925

	Total Cost	Cost per Engine Hour
Yardmasters and yard clerks	$1,183,309	$1.5115
Yard conductors and brakemen	2,718,200	3.4721
Yard switch and signal tenders	138,820	.1773
Yard enginemen	1,384,321	1.7683
Fuel	669,786	.8556
Water	68,909	.0880
Lubricants	21,417	.0274
Other supplies	30,440	.0389
Enginehouse expenses	486,692	.6217
Yard supplies and expenses	63,865	.0816
Total	$6,765,759	$8.6424
Locomotive repairs	$1,646,544	$2.1032
Locomotive depreciation	237,229	.3030
Total	$1,883,773	$2.4062
Grand total	$8,649,532	$11.0486
Locomotive miles		4,697,172
Locomotive hours		782,862

DISTANCE TABLE

NEWPORT NEWS TO KANAWHA AND EASTERN KENTUCKY DISTRICTS

	Miles	Aocumulated Miles
Newport News		0.0
Fulton	73.1	73.1
Gladstone	120.7	193.8
Clifton Forge	111.5	305.3
Hinton	79.9	385.2
Handley Assembly	72.5	457.7
Mines (East of St. Albans)	15.0	472.7
St. Albans	35.9	493.6
Assembly	40.1	533.7
Mines (Coal River Field)	15.0	548.7
Barboursville	65.1	522.8
Assembly	63.9	586.7
Mines (Logan Field)	12.9	599.6
Russell		552.0
Assembly	110.1	662.1
Mines (Big Sandy Field)	13.9	676.0

Exhibit B

BEFORE THE

INTERSTATE COMMERCE COMMISSION

IN THE MATTER OF THE

Application of The Chesapeake and Ohio Railway Company for a Certificate of Public Convenience and Necessity Authorizing Construction and Operation of an Extension of Logan Division—Gilbert to Mullens—and of Winding Gulf Branch—Stone Coal to Mullens, West Virginia.

FINANCE DOCKET No. 4818

Witness Marshall

TRANSPORTATION SAVINGS

Stone Coal Junction to Kenova.					
Existing Route:					
Via Raleigh	168.6	$ 8.88	26,985	$239,626.80	
Proposed Route:					
Via Gilbert	160.4	5.13	26,985	138,433.05	
Saving in cost via proposed route					$101,193.75
Peach Creek to Quinnimont.					
Existing Route:					
Via Barboursville	180.1	$ 8.42	24,420	$205,616.40	
Proposed Route:					
Via Gilbert	114.7	6.43	24,420	157,020.60	
Saving in cost via proposed route					$ 48,595.80
Total savings via proposed routes					$501,466.11

SUMMARY OF ESTIMATED SAVINGS IN COST OF TRANSPORTATION WHICH WILL RESULT FROM THE USE OF PROPOSED EXTENSIONS FOR REROUTING EXISTING COAL TRAFFIC.

Train service cost based on estimated number of cars to be moved during the year 1927, page 29	$501,466.11
Savings in cost of Repairs, Depreciation and Retirement of coal cars, page 33	60,136.88
Saving in time of movement of loaded and empty coal cars Virginian and Chesapeake Coal Traffic, pages 35 and 36	38,569.70
Total Savings	$600,172.69

SUMMARY OF TRAIN SERVICE COSTS PER CAR AND TOTAL COST BASED UPON ESTIMATED NUMBER OF CARS TO BE MOVED DURING THE YEAR 1927.

	Distance	Cost Per Car	No. of Cars	Total Cost	Saving
Elmore to Kenova.					
Existing Routes:					
Via Matoaka	198.9	$11.97	45,770	$547,866.90	
Via Deepwater	151.9	11.54	10,788	124,493.52	
Total cost via existing routes			56,558	$672,360.42	
Proposed Route:					
Via Gilbert	151.2	5.67	56,558	320,683.86	
Saving in cost via proposed route					$351,676.56

DIRECT COST OF TRAIN SERVICE IN TRANSPORTING COAL FROM THE NEW RIVER COAL DISTRICT OF WEST VIRGINIA TO KENOVA, W. VA., VIA EXISTING ROUTES COMPARED WITH THE COST VIA NEW ROUTES WHICH WILL BE CREATED BY THE CONSTRUCTION OF NEW LINES FROM GILBERT TO MULLENS AND STONE COAL JUNCTION TO MULLENS.

ELMORE TO KENOVA VIA MATOAKA.

FROM	TO	Distance Miles	Ruling Grade	Helpers			Rating Gross Tons	Number of Cars	Train Speed	Train Hours	Cost Per Train Hour	Total Cost	Cost Per Car
				Number	Miles	Grade							
Elmore	Matoaka	18.5					3,825	52	8.0	†2.50	$19.00	$ 47.50	$ .91
Elmore	Clark's Gap			2	15.4	2.07	3,825	52	8.0	7.70	17.00	130.90	2.52
Matoaka	Bluestone	15.9	0.63				3,975	54	8.0	2.00	19.00	38.00	.70
Bluestone	Iaeger	46.8	D				3,975	54	10.0	4.68	19.00	88.92	1.65
Iaeger	Williamson	43.8	D				7,380	100	10.0	4.38	19.00	83.22	.83
Williamson	Kenova	73.9	0.25				x6,238	84	10.0	7.39	19.00	140.41	1.67
Total Westbound		198.9											$8.28
Kenova	Williamson	73.9	0.27				1,730	84	12.0	6.16	$19.00	$117.04	$1.39
Williamson	Iaeger	43.8	0.50				2,060	100	12.0	3.65	19.00	69.35	.69
Iaeger	Bluestone	46.8	No service required.										
Bluestone	Matoaka	15.9	1.18				1,112	54	8.0	2.00	19.00	38.00	.70
Matoaka	Elmore	18.5	1.25				1,071	52	8.0	†2.50	19.00	47.50	.91
Total Eastbound		198.9											$3.69
Grand Total Cost per Car													$11.97

x–Same as Peach Creek-Russell.
†–To N. & W. connection.
Cars 53.2 tons net, 73.8 tons gross.

ELMORE TO KENOVA VIA DEEPWATER.

FROM	TO	Distance Miles	Ruling Grade	Helpers Number	Helpers Miles	Helpers Grade	Rating Gross Tons	Number of Cars	Train Speed	Train Hours	Cost Per Train Hour	Total Cost	Cost Per Car
Elmore	Jenny Gap	15.4					3,200	43.4	8.0	1.93	$19.00	$36.67	$ .84
Elmore	Jenny Gap			1	15.4	1.65	3,200	43.4	8.0	3.85	17.00	65.45	1.51
Jenny Gap	Page	36.7	1.10				2,400	32.5	8.0	4.59	19.00	87.21	2.68
Page	Deepwater	8.5	D					x36.0	8.0	1.06	19.00	20.14	.56
Deepwater	Handley	8.3	D					x36.0	8.0	1.04	19.00	19.76	.55
Handley	Kenova	83.0	0.30				5,885	80.0	8.9	9.33	19.00	177.27	2.21
Total Westbound		151.9											$8.35
Kenova	Handley	83.0	0.30				1,648	80.0	9.5	8.74	$19.00	$166.06	$2.08
Handley	Deepwater	8.3	0.27					x36.0	8.0	1.04	19.00	19.76	.55
Deepwater	Page	8.5	1.70					x36.0	8.0	1.06	19.00	20.14	.56
Page	Jenny Gap	36.7	(2.02, 1.75, 1.60)	No service required.									
Jenny Gap	Elmore	15.4	D	No service required.									
Total Eastbound		151.9											$3.19
Grand Total Cost per Car													$11.54

x–Daily average number of cars moving this route.
Cars 53.2 tons net, 73.8 tons gross.
D–Descending grade.

MULLENS AND STONE COAL JUNCTION TO MULLENS.

ELMORE TO KENOVA VIA GILBERT.

FROM	TO	Distance Miles	Ruling Grade	Helpers Number	Helpers Miles	Helpers Grade	Rating Gross Tons	Number of Cars	Train Speed	Train Hours	Cost Per Train Hour	Total Cost	Cost Per Car
Elmore	Peach Creek	70.8	D				6,863	93.0	10.0	7.08	$19.00	$134.52	$1.45
Peach Creek	Kenova	80.4	0.22				6,238	84.5	9.3	8.65	19.00	164.35	1.94
Total Westbound		151.2											$3.39
Kenova	Peach Creek	80.4	0.50				1,741	84.5	11.6	6.93	$19.00	$131.67	$1.56
Peach Creek	Elmore	70.8	0.80				1,916	93.0	10.0	x3.54	19.00	67.26	.72
Total Eastbound		151.2											$2.28
Grand Total Cost per Car													$5.67
STONE COAL JUNCTION TO KENOVA VIA RALEIGH.													
Stone Coal Junction	Raleigh	20.1	Mine run	service.	No change.								
Raleigh	Quinnimont	14.6					3,225	43.7	4.7	3.11	$19.00	$59.09	$1.35
Quinnimont	Handley	50.9					3,690	50.0	10.3	4.94	19.00	93.86	1.88
Handley	Kenova	83.0					5,885	79.8	8.9	9.33	19.00	177.27	2.22
Total Westbound		168.6											$5.45
Kenova	Handley	83.0	0.32				1,644	79.8	9.5	8.74	$19.00	$166.06	$2.08
Handley	Quinnimont	50.9	No servic	e required									
Quinnimont	Raleigh	14.6	2.20				900	43.7	4.7	3.11	19.00	59.09	1.35
Raleigh	Stone Coal Junction	20.1	Mine run	service.	No change								
Total Eastbound		168.6											$3.43
Grand Total Cost per Car													$8.88
STONE COAL JUNCTION TO KENOVA VIA GILBERT.													
Stone Coal Junction	Peach Creek	80.0	D				6,863	93.0	10.0	8.00	$19.00	$152.00	$1.63
Peach Creek	Kenova	80.4	0.22				6,238	84.5	9.3	8.65	19.00	164.35	1.94
Total Westbound		160.4											$3.57
Kenova	Peach Creek	80.4	0.57				1,741	84.5	11.6	6.93	$19.00	$131.67	$1.56
Peach Creek	Stone Coal Junction	†80.0											
Total Eastbound		160.4											$1.56
Grand Total Cost per Car													$5.13

x–One third of westbound trains over new lines returning with eastbound Virginian empties will constitute one-half of the westbound Elmore-Peach Creek trains.
†–Return service charged one-third to Elmore - Peach Creek, two-thirds to Eastbound loads.
Cars 53.2 tons net, 73.8 tons gross.
D–Descending grade.

DIRECT COST OF TRAIN SERVICE IN TRANSPORTING COAL FROM THE NEW RIVER COAL DISTRICT OF WEST VIRGINIA TO KENOVA, W. VA., VIA EXISTING ROUTES COMPARED WITH THE COST VIA NEW ROUTES WHICH WILL BE CREATED BY THE CONSTRUCTION OF NEW LINES FROM GILBERT TO MULLENS AND STONE COAL JUNCTION TO MULLENS.

PEACH CREEK TO QUINNIMONT VIA BARBOURSVILLE.

FROM	TO	Distance Miles	Ruling Grade	Helpers			Rating Gross Tons	Number of Cars	Train Speed	Train Hours	Cost Per Train Hour	Total Cost	Cost Per Car
				Number	Miles	Grade							
Peach Creek	Handley	129.2	0.30				6,671	90.0	10.1	12.79	$19.00	$243.01	$2.70
Barboursville	St. Albans			1	30.0	0.30	6,671	90.0	7.5	4.00	17.00	68.00	.76
Handley	Quinnimont	50.9	0 40				4,186	56.7	8.3	6.13	19.00	116.47	2.05
Total Eastbound		180.1											$5.51
Quinnimont	Handley	50.9	D				1,168	56.7	10.3	4.94	$19.00	$93.86	$1.66
Handley	Peach Creek	129.2	0.50				1,854	90.0	14.9	†1.24	19.00	23.56	.26
Barboursville	Peach Creek	(63.3)	0.50				1,854	90.0	11.6	x4.68	19.00	88.92	.99
Total Westbound		180.1											$2.91
Grand Total Cost per Car													$8.42

PEACH CREEK TO QUINNIMONT VIA NEW LINE.

FROM	TO	Distance Miles	Ruling Grade	Helpers Number	Helpers Miles	Helpers Grade	Rating Gross Tons	Number of Cars	Train Speed	Train Hours	Cost Per Train Hour	Total Cost	Cost Per Car
Peach Creek	Stone Coal Junction	80.0	0.80				3,000	40.7	10.0	8.00	$19.00	$152.00	$3.73
Stone Coal Junction	Raleigh	20.1	Mine run	service.	No change								
Raleigh	Quinnimont	14.6	D				3,225	43.7	4.7	3.11	19.00	59.09	1.35
Total Eastbound		114.7											$5.08
Quinnimont	Raleigh	14.6					900	43.7	4.7	3.11	$19.00	$59.09	$1.35
Raleigh	Stone Coal Junction	20.1	Mine run	service.	No change								
Stone Coal Junction	Peach Creek	80.0	No return	service re	quired								
Total Westbound		114.7											$1.35
Grand Total Cost per Car													$6.43

†–One-seventh of the Eastbound trains return to Peach Creek.
x–Six-sevenths of the Eastbound trains handle Westbound cars to Russell and Eastbound empty cars Russell to Peach Creek.
Cars 53.2 tons net, 73.8 tons gross.
D–Descending grade.

Saving in Cost of Repairs, Depreciation and Retirements of Coal Cars due to movement of Loaded Cars via shorter routes through use of Proposed New Lines.

	Number of Cars.	Distance Hauled.	Car Miles.	Car Miles Saved.
Elmore to Kenova:				
Via Matoaka	45,770	198.9	9,103,653	
Via Deepwater	10,788	151.9	1,638,697	
Total	56,558		10,742,350	
Via Gilbert	56,558	151.2	8,551,570	2,190,780
Stone Coal Junction to Kenova:				
Via Raleigh	26,985	168.6	4,549,671	
Via Gilbert	26,985	160.4	4,328,394	221,277
Peach Creek to Quinnimont:				
Via Barboursville	24,420	180.1	4,398,042	
Via Gilbert	24,420	114.7	2,800,974	1,597,068
Total car miles saved				4,009,125
Cost per car mile for repairs and depreciation				$ 0.015
Saving from use of new line				$ 60,136.88

Saving in Time of Movement of Loaded and Empty Coal Cars resulting from routing Existing Coal Traffic over Proposed New Line.

VIRGINIAN COAL TRAFFIC.

	Time of Movement (Hours).	Days.	Interest, Taxes and Insurance at 40 Cents per Day.
Elmore–Kenova via Matoaka			
Elmore–Matoaka	2.50		
At Matoaka	6.00		
Matoaka–Bluestone	2.00		
At Bluestone	6.00		
Bluestone–Iaeger	4.68		
At Iaeger	3.00		
Iaeger–Williamson	4.38		
At Williamson	5.00		
Williamson–Kenova	7.39		
Total for loaded movement	40.95	1.71	$0.68
Kenova–Williamson	6.16		
At Williamson	5.00		
Williamson–Iaeger	3.65		
At Iaeger (see Note)	1.50		
Iaeger–Bluestone (see Note)	2.34		
At Bluestone	6.00		
Bluestone–Matoaka	2.00		
At Matoaka	6.00		
Matoaka–Elmore	2.50		
Total for empty movement	35.15	1.46	$0.58
Total for loaded and empty movement	76.10	3.17	$1.26

Note.—It is assumed that one-half the cars for westbound movement are supplied by the Virginian and these identical cars returned to the Virginian via the same route and that the other one-half are supplied by Norfolk & Western, from the east at Bluestone and such cars returning from the west are used at Iaeger; therefore only one-half of movement time is taken (for the Virginian cars) Iaeger to Bluestone.

Elmore–Kenova via Deepwater			
Elmore–Jenny Gap	1.93		
Jenny Gap–Page	4.59		
At Page	6.00		
Page–Deepwater	1.06		
At Deepwater	6.00		
Deepwater–Handley	1.04		
At Handley	5.00		
Handley–Kenova	9.33		
Total for loaded movement	34.95	1.46	$0.58
Kenova–Handley	8.74		
At Handley	5.00		
Handley-Deepwater	1.04		
At Deepwater	6.00		
Deepwater–Page	1.06		
At Page (see Note)	3.00		
Page–Elmore (see Note)	3.26		
Total for empty movement	28.10	1.17	$0.47
Total for loaded and empty movement	63.05	2.63	$1.05

Note.—Assuming that one-half of these cars are supplied by Chesapeake & Ohio only such C. & O. cars would move beyond Page; the Virginian cars would be used at Page.

Saving in Time of Movement of Loaded and Empty Coal Cars resulting from routing Existing Coal Traffic over Proposed New Line.

VIRGINIAN COAL TRAFFIC.

	Time of Movement (Hours)	Days	Interest, Taxes and Insurance at 40 Cents per Day
Elmore–Kenova via Gilbert			
Elmore–Peach Creek	7.08		
At Peach Creek	5.00		
Peach Creek–Kenova	8.65		
Total for loaded movement	20.73	0.86	$0.34
Kenova–Peach Creek	6.93		
At Peach Creek–½ (See Note 1)	2.50		
Peach Creek–Elmore–½ (See Note 1)	3.54		
Quinnimont–Raleigh–½ (See Note 2)	1.56		
At Raleigh–½ (See Note 2)	3.00		
Raleigh–Pemberton–½ (See Note 2)	1.00		
Total for empty movement	18.53	0.77	$0.31
Total loaded and empty movement	39.26	1.63	$0.65

Note 1.—It is assumed that one-half of the empty cars for this movement will be supplied by the Virginian and these cars will move empty Peach Creek to Elmore.

Note 2.—It is assumed that the other one-half of the empty cars will be supplied by Chesapeake & Ohio thru Quinnimont, Raleigh and Pemberton and used by the Virginian in Sections 13, 14 and 15, thereby saving up-hill haul by mine run crews from Elmore to Stone Coal Junction and with respect to Section 13 all the way to Pemberton.

SUMMARY FOR VIRGINIAN TRAFFIC.

	Total Interest, Taxes and Insurance	Savings
Existing Routes		
Elmore–Kenova via Matoaka–45,770 cars at $1.26	$57,670.20	
Elmore–Kenova via Deepwater–10,788 cars at $1.05	11,327.40	
Total for existing routes	$68,997.60	
Proposed Route		
Elmore–Kenova via Gilbert–56,558 cars at $0.65	$36,762.70	
Total for proposed route	$36,762.70	
Difference–saving		$32,234.90

Saving in Time of Movement of Loaded and Empty Coal Cars resulting from routing Existing Coal Traffic over Proposed New Line.

CHESAPEAKE AND OHIO COAL TRAFFIC.

	Time of Movement (Hours)	Days	Interest, Taxes and Insurance at 40 Cents per Day
Stone Coal Junction—Kenova via Raleigh.			
Stone Coal Junction-Raleigh	4.00		
At Raleigh	6.00		
Raleigh-Quinnimont	3.11		
At Quinnimont	6.00		
Quinnimont-Handley	4.94		
At Handley	5.00		
Handley-Kenova	9.33		
Total loaded movement	38.38	1.60	$0.64

Note.—Movement of empty cars would be the same as at present.

	Time of Movement (Hours)	Days	Interest, Taxes and Insurance at 40 Cents per Day
Stone Coal Junction—Kenova via Gilbert.			
Stone Coal Junction-Peach Creek	8.00		
At Peach Creek	5.00		
Peach Creek-Kenova	8.65		
Total loaded movement	21.65	.90	$0.36

Note.—Movement of empty cars would be the same as at present.

	Time of Movement (Hours)	Days	Interest, Taxes and Insurance at 40 Cents per Day
Peach Creek—Quinnimont via Barboursville.			
Peach Creek-Handley	12.79		
At Handley	5.00		
Handley-Quinnimont	6.13		
Total loaded movement	23.92	1.00	$0.40

Note.—Movement of empty cars would be the same as at present.

Peach Creek—Quinnimont via Gilbert.			
Peach Creek-Stone Coal Junction	8.00		
At Stone Coal Junction	6.00		
Stone Coal Junction-Raleigh	4.00		
At Raleigh	6.00		
Raleigh-Quinnimont	3.11		
Total loaded movement	27.11	1.13	$0.45

Note.—Movement of empty cars would be the same as at present.

SUMMARY FOR CHESAPEAKE AND OHIO COAL TRAFFIC.

	Total Interest, Taxes and Insurance	Savings
Existing Routes.		
Stone Coal Junction-Kenova via Raleigh, 26,985 cars at $0.64	$17,270.40	
Peach Creek-Quinnimont via Barboursville, 24,420 cars at $0.40	9,768.00	
Total for existing routes	$27,038.40	
Proposed Routes.		
Stone Coal Junction-Kenova via Gilbert, 26,985 cars at $0.36	$9,714.60	
Peach Creek-Quinnimont via Gilbert, 24,420 cars at $0.45	10,989.00	
Total for proposed routes	$20,703.60	
Difference—saving		$6,334.80

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

Estimated Cost per Train Hour Based Upon Operating Performance for the First Seven Months of 1927.

	Hinton Division	Logan Division	Huntington Division	System
Cost per Train Hour:				
Wages and Train Supplies	$ 8.303	$ 8.718	$ 7.433	$ 7.835
Other Expenses	10.671	9.433	9.913	11.266
Total	$18.974	$18.151	$17.346	$19.101
Ratio of Locomotive Miles to Train Miles	1.275	1.107	1.100	1.121
Cost per Train Hour less Proportionate Cost of Helper and Light Mileage:				
Wages and Train Supplies	$ 6.512	$ 7.875	$ 6.757	$ 6.989
Other Expenses	8.369	8.521	9.012	10.050
Total	$14.881	$16.396	$15.769	$17.039
Average Tractive Power of Locomotives in Service	61,167	64,791	62,455	62,537
Proportionate Cost for Locomotive of 74,200 Pounds Tractive Power:				
Wages and Train Supplies	$*6.512	$*7.875	$*6.757	$*6.989
Other Expenses	10.152	9.757	10.706	11.919
Total	$16.664	$17.632	$17.463	$18.908
Add Interest on Value of Locomotive	1.989	1.989	1.989	1.989
Total	$18.653	$19.621	$19.452	$20.897

*–Not proportionate to tractive power.

COMPUTATION OF INTEREST.

Train Hours—System	743,067
Ratio of Locomotive Miles to Train Miles	1.121
Locomotive Hours Estimated	832,978
Number of Locomotives Assigned to Freight Service, including Shopped and Stored	638
Hours per Locomotive Assigned	1,306
Value of Locomotive of 74,200 Pounds Tractive Power	$74,200
Interest at 6 per cent per annum	$ 4,452
Interest for Seven Months	$ 2,597
Interest for Locomotive Hour	$ 1.989

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

FREIGHT TRAIN AND ENGINE EXPENSES.

Seven Months Ended July 31, 1927.

SYSTEM	Expense	Cost per Train Mile	Cost per Loco. Mile	Cost per Train Hour	Cost per 1,000 Gross Ton Miles	Cost per 1,000 Net Ton Miles
Locomotive Repairs	$ 4,384,819	$ .527	$ .470	$ 5.901	$ .196	$ .364
Locomotive Depreciation	889,336	.107	.095	1.197	.040	.074
Train Enginemen	2,409,080	.289	.258	3.242	108	.200
Fuel for Locomotives	2,102,495	.253	.225	2.829	.094	.174
Water for Locomotives	209,468	.025	.023	.282	.009	.017
Lubricants for Locomotives	89,321	.011	.010	.121	.004	.007
Other Supplies for Locomotives	48,778	.006	.005	.066	.002	.004
Engine House Expenses	646,578	.078	.069	.870	.029	.054
Trainmen	2,773,328	.333	.297	3.732	.124	.230
Train Supplies and Expenses	640,110	.077	.069	.861	.029	.053
Total	$14,193,313	$ 1.706	$ 1.521	$ 19.101	$ .635	$ 1.177

Train Miles	8,321,826
Locomotive Miles	9,330,609
Train Hours	743,067
Gross Ton Miles (1,000)	22,350,111
Net Ton Miles (1,000)	12,061,678

HUNTINGTON DIVISION.	Expense	Cost per Train Mile	Cost per Loco. Mile	Cost per Train Hour	Cost per 1,000 Gross Ton Miles	Cost per 1,000 Net Ton Miles
Locomotive Repairs	$ 722,922	$ .623	$ .566	$ 5.335	$ .219	$ .386
Locomotive Depreciation	143,188	.123	.112	1.056	.043	.077
Train Enginemen	413,228	.356	.323	3.050	.126	.220
Fuel for Locomotives	287,628	.248	.225	2.123	.087	.154
Water for Locomotives	37,852	.033	.030	.279	.012	.020
Lubricants for Locomotives	12,669	.011	.010	.094	.004	.007
Other Supplies for Locomotives	7,345	.006	.006	.054	.002	.004
Engine House Expenses	131,693	.113	.103	.972	.040	.070
Trainmen	508,776	.438	.398	3.754	.155	.272
Train Supplies and Expenses	85,255	.073	.067	.629	.026	.046
Total	$2,350,550	$ 2.024	$ 1.840	$ 17.346	$ .714	$ 1.256

Train Miles	1,161,164
Locomotive Miles	1,277,522
Train Hours	135,507
Gross Ton Miles (1,000)	3,292,829
Net Ton Miles (1,000)	1,871,386

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

FREIGHT TRAIN AND ENGINE EXPENSES.

Seven Months Ended July 31, 1927.

LOGAN DIVISION.	Expense	Cost per Train Mile	Cost per Loco. Mile	Cost per Train Hour	Cost per 1,000 Gross Ton Miles	Cost per 1,000 Net Ton Miles
Locomotive Repairs	$ 332,114	$ .626	$ .566	$ 5.036	$ .193	$ .347
Locomotive Depreciation	53,959	.102	.092	.818	.031	.056
Train Enginemen	233,531	.440	.397	3.540	.136	.244
Fuel for Locomotives	184,904	.349	.315	2.804	.107	.193
Water for Locomotives	8,140	.015	.014	.124	.005	.009
Lubricants for Locomotives	6,142	.012	.010	.093	.004	.007
Other Supplies for Locomotives	3,207	.006	.006	.049	.002	.003
Engine House Expenses	33,558	.063	.057	.509	.020	.035
Trainmen	295,382	.556	.503	4.479	.172	.309
Train Supplies and Expenses	46,068	.087	.078	.699	.027	.048
Total	$1,197,005	$ 2.256	$ 2.038	$ 18.151	$ .697	$ 1.251

Train Miles	530,606
Locomotive Miles	587,248
Train Hours	65,948
Gross Ton Miles (1,000)	1,718,004
Net Ton Miles (1,000)	957,142

HINTON DIVISION.	Expense	Cost per Train Mile	Cost per Loco. Mile	Cost per Train Hour	Cost per 1,000 Gross Ton Miles	Cost per 1,000 Net Ton Miles
Locomotive Repairs	$ 547,198	$ .801	$ .628	$ 5.974	$ .369	$ .644
Locomotive Depreciation	90,704	.133	.104	.990	.061	.106
Train Enginemen	358,542	.525	.412	3.915	.242	.422
Fuel for Locomotives	224,952	.329	.258	2.456	.152	.265
Water for Locomotives	12,590	.018	.015	.138	.009	.015
Lubricants for Locomotives	7,925	.012	.009	.087	.005	.009
Other Supplies for Locomotives	5,653	.008	.006	.061	.004	.007
Engine House Expenses	88,372	.129	.101	.965	.060	.104
Trainmen	361,481	.529	.415	3.947	.244	.425
Train Supplies and Expenses	40,419	.059	.046	.441	.027	.048
Total	$1,737,836	$ 2.543	$ 1.994	$ 18.974	$ 1.173	$ 2.045

Train Miles	683,469
Locomotive Miles	871,531
Train Hours	91,592
Gross Ton Miles (1,000)	1,481,576
Net Ton Miles (1,000)	849,909

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

FREIGHT TRAIN AND ENGINE EXPENSES.

Year 1926.

SYSTEM	Expense	Cost per Train Mile	Cost per Loco. Mile	Cost per Train Hour	Cost per 1,000 Gross Ton Miles	Cost per 1,000 Net Ton Miles
Locomotive Repairs	$ 7,536,569	$ .510	$ .461	$ 5.440	$ .196	$ .359
Locomotive Depreciation	1,483,914	.100	.090	1.071	.038	.071
Train Enginemen	4,324,267	.293	.265	3.121	.112	.206
Fuel for Locomotives	3,815,580	.258	.234	2.754	.099	.182
Water for Locomotives	367,947	.025	.023	.266	.010	.018
Lubricants for Locomotives	131,891	.009	.008	.095	.003	.006
Other Supplies for Locomotives	88,455	.006	.005	.064	.002	.004
Engine House Expenses	1,070,677	.073	.066	.773	.029	.051
Trainmen	4,775,827	.323	.293	3.447	.124	.228
Train Supplies and Expenses	1,094,265	.074	.067	.790	.028	.052
Total	$24,689,392	$ 1.671	$ 1.512	$ 17.821	$ .641	$ 1.177

Train Miles	14,772,692
Locomotive Miles	16,326,785
Train Hours	1,385,416
Gross Ton Miles (1,000)	38,500,793
Net Ton Miles (1,000)	20,968,059

HUNTINGTON DIVISION.	Expense	Cost per Train Mile	Cost per Loco. Mile	Cost per Train Hour	Cost per 1,000 Gross Ton Miles	Cost per 1,000 Net Ton Miles
Locomotive Repairs	$1,215,972	$ .621	$ .566	$ 5.138	$ .231	$ .401
Locomotive Depreciation	237,445	.121	.111	1.003	.045	.078
Train Enginemen	727,743	.370	.339	3.075	.138	.240
Fuel for Locomotives	514,452	.263	.240	2.174	.098	.170
Water for Locomotives	80,496	.041	.037	.340	.015	.027
Lubricants for Locomotives	18,727	.010	.009	.079	.004	.006
Other Supplies for Locomotives	13,501	.007	.006	.057	.003	.004
Engine House Expenses	217,803	.111	.102	.921	.040	.072
Trainmen	876,977	.448	.408	3.706	.166	.290
Train Supplies and Expenses	138,464	.071	.064	.585	.026	.046
Total	$4,041,580	$ 2.063	$ 1.882	$ 17.078	$ .766	$ 1.334

Train Miles	1,959,228
Locomotive Miles	2,147,253
Train Hours	236,661
Gross Ton Miles (1,000)	5,272,926
Net Ton Miles (1,000)	3,028,841

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

FREIGHT TRAIN AND ENGINE EXPENSES.

Year 1926.

LOGAN DIVISION.	Expense	Cost per Train Mile	Cost per Loco. Mile	Cost per Train Hour	Cost per 1,000 Gross Ton Miles	Cost per 1,000 Net Ton Miles
Locomotive Repairs	$ 747,856	$ .819	$ .728	$ 6.465	$ .271	$ .486
Locomotive Depreciation	86,110	.094	.084	.744	.032	.056
Train Enginemen	405,489	.444	.395	3.505	.147	.263
Fuel for Locomotives	322,853	.352	.315	2.791	.117	.210
Water for Locomotives	18,661	.020	.018	.161	.007	.011
Lubricants for Locomotives	9,044	.010	.009	.078	.003	.006
Other Supplies for Locomotives	6,017	.007	.006	.052	.002	.004
Engine House Expenses	60,006	.066	.058	.519	.022	.039
Trainmen	482,087	.528	.469	4.167	.175	.313
Train Supplies and Expenses	74,788	.083	.073	.646	.027	.049
Total	$2,212,911	$ 2.423	$ 2.155	$ 19.128	$ .803	$ 1.437

Train Miles	913,306
Locomotive Miles	1,026,839
Train Hours	115,687
Gross Ton Miles (1,000)	2,754,512
Net Ton Miles (1,000)	1,540,275

HINTON DIVISION.	Expense	Cost per Train Mile	Cost per Loco. Mile	Cost per Train Hour	Cost per 1,000 Gross Ton Miles	Cost per 1,000 Net Ton Miles
Locomotive Repairs	$1,013,268	$ .730	$ .639	$ 5.592	$ .356	$ .617
Locomotive Depreciation	144,882	.104	.092	.800	.051	.088
Train Enginemen	638,869	.460	.403	3.525	.224	.389
Fuel for Locomotives	419,660	.302	.265	2.316	.147	.256
Water for Locomotives	28,829	.022	.018	.159	.010	.018
Lubricants for Locomotives	10,217	.007	.006	.056	.004	.006
Other Supplies for Locomotives	7,979	.006	.005	.044	.003	.005
Engine House Expenses	140,766	.102	.089	.777	.049	.086
Trainmen	643,198	.464	.406	3.549	.226	.393
Train Supplies and Expenses	72,664	.052	.046	.401	.025	.044
Total	$3,120,332	$ 2.249	$ 1.969	$ 17.219	$ 1.095	$ 1.902

Train Miles	1,387,590
Locomotive Miles	1,584,634
Train Hours	181,215
Gross Ton Miles (1,000)	2,848,466
Net Ton Miles (1,000)	1,640,721

LOCOMOTIVE DATA.

THE CHESAPEAKE AND OHIO RAILWAY COMPANY.

Year	No. of Locomotives (Steam)	Repairs	Depreciation	Retirements	Total	Average Cost per Annum	Total Tractive Power (pounds)	Average Tractive Power (pounds)
1921	946	$ 6,119,930	$ 492,448	$ 1,998	$ 6,614,376	$ 6,992	43,852,169	46,355
1922	943	6,236,489	516,230	*8,870*	6,743,849	7,151	43,791,146	46,438
1923	931	7,965,408	531,883	277,943	8,775,234	9,426	44,765,338	48,083
1924	1,005	9,562,831	852,111	283,527	10,698,469	10,645	52,287,303	52,027
1925	995	11,425,962	1,306,329	187,135	12,919,426	12,984	52,649,867	52,914
1926	1,049	10,720,970	1,483,914	41,677	12,246,561	11,675	57,613,105	54,922

NORFOLK AND WESTERN RAILWAY COMPANY.

Year	No. of Locomotives (Steam)	Repairs	Depreciation	Retirements	Total	Average Cost per Annum	Total Tractive Power (pounds)	Average Tractive Power (pounds)
1921	1,063	$ 6,432,471	$915,560	$ 813	$ 7,348,844	$ 6,913	52,910,250	49,775
1922	1,058	9,154,638	788,511	2,503	9,945,652	9,400	52,695,584	49,807
1923	1,029	10,063,210	850,396	65,882	10,979,488	10,670	54,817,633	53,273
1924	1,013	10,429,445	896,275	90,007	11,415,727	11,269	54,654,416	53,953
1925	993	9,616,848	912,611	64,500	10,593,959	10,669	54,017,482	54,398
1926	925	9,558,392	922,547	169,122	10,650,061	11,514	53,280,528	57,601

VIRGINIAN RAILWAY COMPANY

Year	No. of Locomotives (Steam)	Repairs	Depreciation	Retirements	Total	Average Cost per Annum	Total Tractive Power (pounds)	Average Tractive Power (pounds)
1921	145	$ 1,685,342	$114,251	----------	$ 1,799,593	$12,411	10,045,000	69,275
1922	146	1,617,696	114,108	$8,443	1,740,247	11,920	10,160,000	69,589
1923	161	2,201,977	121,539	1,874	2,325,390	14,443	11,678,750	72,539
1924	161	2,037,919	139,656	----------	2,177,575	13,525	11,678,750	72,539
1925	161	1,892,417	139,549	----------	2,031,966	12,621	11,683,100	72,566
1926	161	1,711,102	139,638	2	1,850,742	11,495	11,683,100	72,566

NOTE.—Italics denote red figures.

FREIGHT CAR DATA.

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

Year	No. of Freight Cars	Repairs	Depreciation	Retirements	Total	Average Cost per Annum	No. Freight Car Miles (Thousands)	Average Cost per Freight Car Mile
1921	51,281	$ 9,417,667	$1,427,093	$ 137,386	$10,982,146	$ 214	423,957	$ .026
1922	52,000	11,575,991	1,550,403	173,707	13,300,101	256	431,451	.031
1923	50,845	11,741,604	1,608,762	3,533,243	16,883,609	332	565,305	.030
1924	51,988	10,636,066	2,323,079	2,649,459	15,608,604	300	653,525	.024
1925	56,551	9,673,906	3,499,804	720,174	13,893,884	246	779,115	.018
1926	54,851	10,053,967	3,522,833	453,696	14,030,496	256	856,492	.016

NORFOLK AND WESTERN RAILWAY COMPANY.

Year	No. of Freight Cars	Repairs	Depreciation	Retirements	Total	Average Cost per Annum	No. Freight Car Miles (Thousands)	Average Cost per Freight Car Mile
1921	46,254	$ 7,240,225	$ 1,698,538	$ 388,373	$ 9,327,136	$ 202	387,994	$ .024
1922	47,461	8,015,645	1,563,316	1,119,013	10,697,974	225	462,561	.023
1923	41,142	5,790,826	1,771,068	3,466,334	11,028,228	268	481,708	.023
1924	42,171	4,336,308	1,828,649	1,712,844	7,877,801	187	498,934	.016
1925	45,916	4,938,350	2,261,333	563,258	7,762,941	169	565,572	.014
1926	45,750	4,464,551	2,286,014	103,261	6,853,826	150	662,550	.010

VIRGINIAN RAILWAY COMPANY.

Year	No. of Freight Cars	Repairs	Depreciation	Retirements	Total	Average Cost per Annum	No. Freight Car Miles (Thousands)	Average Cost per Freight Car Mile
1921	9,804	$ 1,374,342	$329,405	$ 13,662	$ 1,717,409	$ 175	80,313	$ .021
1922	9,676	2,313,297	335,248	60,656	2,709,201	280	88,667	.031
1923	9,204	2,164,209	325,999	110,856	2,601,064	283	104,557	.025
1924	10,308	1,038,254	435,335	7,953	1,481,542	144	86,575	.017
1925	10,289	1,214,720	445,900	7,105	1,667,725	162	83,077	.020
1926	10,280	1,455,502	446,738	1,589	1,903,829	185	101,152	.019

DISCUSSION BY C. P. HOWARD

The undersigned objects to the report presented by the Chairman of Sub-Committee No. 6 for the following reasons:

It presents a short-cut formula which is a statistical rather than an engineering solution of the problem, ignoring physical differences between lines except the rate of ruling grade and length of line.

It is based primarily on an assumption that all expenses of train service vary directly with the number of train hours. The principal expenses of train service are train and engine wages, fuel, and locomotive maintenance. No proof is given that the train hour can be relied on as an accurate measure of such expenses. Of course it is a proper unit for the measurement of wages when the speed is under 12½ miles per hour, but not when, as in the example given in the report, the speed is considerably in excess of 12½ miles per hour. Needless to say, no proof is given, nor could be given, that fuel consumption may safely be estimated as varying directly with the number of train or engine hours. The formula corrects for variation in the tractive power of different locomotives, but that is not enough. The amount of fuel consumption depends not only on the number of hours but on what the engine is doing during those hours. The rate of fuel consumption for a given engine may vary anywhere from 4000 or 5000 pounds of coal per hour or more, when working at maximum effort, down to about 1000 pounds per hour when drifting, or 600 pounds per hour when standing on the sidetrack. For more powerful engines it will vary probably in about the same ratio. As the rate of fuel consumption will vary so widely according to the amount of energy the locomotive is putting forth at different times and on different portions of the run, the method of total resistances is sometimes employed, as set forth in the Manual. Thus, if total resistance per ton of train is 25 per cent greater on one division than on another the fuel consumption may be expected to vary approximately in the same ratio. This does not allow for fuel consumed during stops or in accelerating from one speed to another. If greater accuracy is desired the speed-curve or graphical method may be resorted to as indicated in the 1925 Supplement to the Manual.

Locomotive repairs are generally assumed to vary approximately with mileage rather than hours. Correction for the difference in size or tractive power of the locomotive should of course be made. If there is any data tending to prove that locomotive repairs vary with hours rather than with mileage, that data should be produced. Probably no one would seriously contend that increasing the speed over a division from 10 to 20 miles per hour would cut locomotive repairs in half, but such a result would be indicated by the proposed formula.

The fact that heavy trains take more time to go over the reduced grades of a division than the lighter trains over the same division before grade reduction is said to be one of the most prolific causes why certain grade revisions in the past have failed to realize the benefits anticipated. The reason is fairly obvious. Take a division which has two or more limiting grades of 0.6 per cent, aggregating but a short portion, say 10 per cent, of the total length of the division; the rest of the division having limiting grades of not over 0.3 per cent. If the 0.6 per cent grades are reduced to 0.3 per cent, the train load can be increased about 50 per cent. But over most of the division the grades are unchanged and the increase in the weight of train cannot be accomplished without a sacrifice of speed, and it may be necessary to cut down the weight of train in order to get over the division on time.

A study of just such a case is published in A.R.E.A. Vol. 15, Part 2, pages 2-27. The division was 130 miles long, double tracked, and carried a heavy traffic. The use of the graphic or speed-curve method indicated for the revised line approximately 15 per cent increase in time, 10 per cent increase in fuel consumption per hour, and 27 per cent increase in fuel consumption per train over the whole division.

On page 11 of the report it is assumed in the example given that the decrease in number of trains consequent on the heavier train loads over the revised line will decrease the traffic density enough to offset the decrease in speed, and the average time over the whole division is assumed to be unchanged. Of course this cannot generally be counted on to produce such results. There may be no particular congestion of traffic on the line before revision, or the proposed revision may be alternate to a plan of adding more passing tracks, and additional main track, or other means for relieving congestion—or additional traffic may be contemplated which will make the density as great as it was before.

But suppose, due to decreased density of traffic, delays at passing or meeting points can be cut down sufficiently to compensate for the slower running speed with the heavier train, and the average speed on the revised line is assumed to be the same as before revision. This assumption is made in the example given in the proposed report. The formula then becomes identical with the train mile formula. Thus, formula (1) of proposed report may be written:

$T = C \times H$; in which T = total cost of train service, C = cost per train hour and H = number of train hours. The speed, S, being the same on each line, the equation may be written:

$T = \frac{C}{S} \times HS$, which is the cost per train mile times the number of train miles; an old friend under a different name. It has its advantages but its faults are well known. It ignores the effect of speed, rise and fall, and all physical characteristics of the line except mileage. With the heavier train on the reduced grade the actual running time to move the train over the road will probably be materially increased, fuel consumed per hour further increased; to compensate for which the possible reduction in the small amount consumed while standing will be wholly inadequate. Moreover, for any one of a number of causes, as above noted, the expectation of reducing time lost in delays may be wholly illusory. The proposed method so applied is therefore likely to underestimate the cost of train service on the new line. Of course there is another way out of the difficulty—cut the tonnage on the revised line to increase speed. But that adds to the number of trains necessary to handle the tonnage.

Suppose, however, a reduction in average speed is anticipated. Assume, for example, that the speed on the existing line is 15 miles per hour, with an estimated speed on the revised line of 12½ miles per hour, the length of the division remaining unchanged. The number of train hours will be increased 20 per cent. According to the formula all expenses of train service, wages, fuel, locomotive repairs, etc., will be increased 20 per cent.

As a matter of fact there would be no increase in wages—wages would be on the mileage basis in both cases. Fuel would probably be increased considerably more than 20 per cent, perhaps nearly twice as much, say 35 per cent, as there would probably be an increase in the consumption per hour. We have no data to indicate that locomotive repairs would either increase or decrease with a decrease in speed. It is generally assumed that for locomotives of the same size or tractive power repairs vary directly with their mileage, and in the absence of any proof to the contrary it seems reasonable to assume this to be a fact. Therefore in this case the 20 per cent increase in locomotive repairs indicated by the formula appears to be wholly unsupported.

According to the system data given in Table I of proposed report these three items constitute nearly 80 per cent of the total cost per train hour, viz., wages, $7.08; fuel, $2.78; locomotive repairs, $5.74. For the two larger items which together amount to $12.82, the 20 per cent increase indicated by the formula would be $2.56 per hour—which may be rejected as clearly erroneous. Twenty per cent increase in fuel would amount to 56 cents. It seems probable it would be considerably greater, say about $1.00. According to our best information the increase in cost per train hour for those three items may therefore be estimated at approximately $1.00 instead of $3.12 as indicated by proposed formula, or about 6 per cent instead of 20 per cent. In this case the formula gives too great a cost. In the other it was too small.

Even though the speed is different, if it does not exceed 12½ miles per hour on either line one serious error in the use of the formula will be eliminated. Wages then vary in proportion to train hours.

Our general objection to the use of this formula is that it attempts to apply average costs per train hour to important items of cost which do not vary with the train hour. The result of its application must result in serious error in many cases. The resulting error may be an overestimate or underestimate of the benefits to be derived from the proposed revision. The use of the formula may lead to the selection of a decidedly inferior line where two or more alternate lines are considered.

Supplement to Manual, August, 1925, recommends general methods for the solution of the most difficult problems as to economic value of grade and line revisions: (1) the determination of fuel consumption in proportion to line resistance and (2) the determination of both speed and fuel consumption by the graphic or speed-curve method. The latter is the only known method by which all essential elements which effect speed and fuel consumption, grade, rise and fall, momentum, delays, etc., may be considered in their proper relation. There is no short cut method by which this can be done. There are fundamental errors in every short cut formula so far advanced, whether based on the train mile, ton mile, train hour, or other unit.

It is admitted that short cut methods must be used in many and probably in most cases; but it may not safely be assumed that they will give correct results. They are rough approximations. The short cut method here proposed has been most carefully worked out as to its details and has the advantage of great simplicity. It will no doubt prove useful in many cases where no great accuracy is required and time is not available for more careful analysis. In view of its fundamental inconsistences, however, we do not feel that it should be recommended by the Committee. Some other short-cut method may be found which will be more accurate and can be applied with practically the same facility.

DISCUSSION BY W. L. R. HAINES

The following discussion is submitted in connection with tentative report of Sub-Committee 6, Committee XVI—Economics of Railway Location.

No "short-cut" method can be expected to fully take the place of a detailed analysis, the first step in which should be the preparation of a "speed-time" profile. From such a profile the "working-rate" of the locomotive on the various parts of the line can be determined and the fuel-consumption estimated.

Such a profile will sometimes develop surprising data. In an investigation now in progress on the P.R.R., a comparison between the same terminals via three different routes showed the following

	Line O Present	*Line N*	*Line R*
Length of line-miles	110.9	104.8	94.4
Ruling grade	1.00%	0.3%	0.55%
Entire time, start to stop	3.13 hrs.	5.4 hrs.	4.1 hrs.
Average speed, miles per hour	35.4	19.4	23.0
Tons per hour	623	889	780
Tons per hour increase over present line.		39.5%	25.2%

I do not agree with the theory that a correct comparison of the cost of moving freight between terminals may be determined on the basis of train hours.

Wages of engine and train crews are based on a combination of mileage and hours. The "basic day" is 100 miles in 8 hours; an average speed of 12½ miles per hour. For any different average speed, payment is made for miles or hours, whichever is the greater. Thus, if the average speed is increased to 20 miles per hour, 160 miles could be made in 8 hours, for which the payment would be 1.6 days, yet the train-hours would be the same. Or, if for any cause on a 160 mile run the average speed was reduced to 10 miles per hour, 16 hours would be required, for which the payment would be 2.0 days. This illustrates the fallacy of basing wages on a train-hour basis.

Locomotive repairs certainly do not vary directly with train-hours, nor with train-miles. However, the relation between train-miles and repairs is more direct than that between train-hours and repairs. The usual statistical reports give information from which the cost per train-mile can be obtained, making this a convenient figure to use. This applies also to costs of fuel, water, lubricants, and other expenses.

In using such train-mile costs, allowance should be made for that portion of such costs which do not vary with train-load (grades) and distance. Some fuel consumption is due to firing-up and standing-time. A large proportion of enginehouse expenses is independent of distance and time.

I also do not agree that the measure of the economic value of improvements may be determined on the basis of the return on the amount charged to Additions and Betterments.

In determining the value of an improvement the net return on the entire out-of-pocket cost, i. e., gross cost less salvage, should be used, as all the new money to be invested must eventually be paid for.

REPORT OF COMMITTEE V—TRACK

J. V. Neubert, *Chairman;*
J. B. Akers,
W. G. Arn,
W. H. Bevan,
C. W. Breed,
H. W. Brown,
W. G. Brown,
L. H. Bond,
E. W. Caruthers,
H. R. Clarke,
J. W. DeMoyer,
J. E. Deckert,
L. W. Deslauriers,
E. B. Entwisle,
J. M. Fair,
C. J. Geyer,
F. S. Hales,
W. J. Harris,
O. F. Harting,
F. W. Hillman,
E. T. Howson,
C. R. Harding, *Vice-Chairman;*
W. G. Hulbert,
H. D. Knecht,
F. R. Masters,
C. M. McVay,
J. de N. Macomb,
J. C. Mock,
J. B. Myers,
A. J. Neafie,
G. A. Peabody,
W. H. Petersen,
O. C. Rehfuss,
I. H. Schram,
G. J. Slibeck,
G. M. Strachan,
C. R. Strattman,
J. B. Strong,
E. D. Swift,
T. P. Warren,
J. R. Watt,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith reports on the subjects assigned, as follows:

(1) Revision of Manual (Appendix A).

(2) Continue critical review of the material now appearing in publications of the Association relating to curve elevation; ascertain existing views and practices of the railways; and recommend such changes as are found desirable (Appendix B).

(3) Continue the study of detailed plans of switches, frogs, crossings and slip switches (Appendix C).

(4) Continue the study of track construction in paved streets (Appendix D).

(5) Continue study and report on design and specifications for foundations under railway crossings; also proper methods for tie spacing and timbering under railway crossings (Appendix E).

(6) Continue study and report on methods of reducing rail wear on curves, with particular reference to oiling the rail or wheel flanges, collaborating with Committee IV—Rail (Appendix F).

(7) Continue critical review of material in former Proceedings with respect to the cause and effect of brine drippings, collaborating with Committee IV—Rail, and Committee XV—Iron and Steel Structures (Appendix G).

(Not specifically assigned.) Prepare plans and specifications for track tools (Appendix H).

(8) Outline of work for ensuing year. The Committee's recommendations are given under "Recommendations for Future Work."

Bulletin 314, February, 1929.

Action Recommended

1. That the changes in the Manual, outlined in Appendices A and B, be approved and that revised version be substituted for the present recommendations in the Manual.

2. That plans in Appendix E and certain plans in Appendix C be adopted as recommended practice and published in the Manual as outlined in these reports.

3. That further data as outlined in Appendix C, also reports on other subjects as outlined in Appendices B, F, G and H be received as information.

Recommendations for Future Work

(1) Revision of Manual.

(2) Prepare plans and specifications for track tools.

(3) Continue the study of detailed plans of switches, frogs, crossings and slip switches.

(4) Continue the study of track construction in paved streets.

(5) Continue the study of corrosion of rail and fastenings in tunnels, collaborating with Committee IV—Rail.

(6) Continue the study and report on methods of reducing rail wear on curves with particular reference to oiling the rail or wheel flanges, collaborating with Committee IV—Rail.

(7) Continue critical review of material in former Proceedings with respect to the cause and effect of brine drippings, collaborating with Committee IV—Rail, and Committee XV—Iron and Steel Structures.

(8) Outline of work for ensuing year.

Respectfully submitted,

The Committee on Track,

J. V. Neubert, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

J. V. Neubert, Chairman, Sub-Committee; C. R. Harding, W. G. Arn, C. W. Breed, E. W. Caruthers, C. J. Geyer, F. S. Hales, O. F. Harting, C. M. McVay, J. B. Myers, G. M. Strachan, J. R. Watt.

The Committee recommends the following changes in the Manual and in adopted plans and specifications:

Withdraw graphic chart shown on page 189 of 1921 Manual, entitled "Speeds of trains on curves—overturning speeds—resultant through gage line—Height of center of gravity 84 inches."

Also the following changes on page 184 of 1921 Manual are recommended:

First Paragraph on Page 184

Present Form	*Proposed Form*
(a) Elevation of Curves: The approximate formula: $E = .00066\ DS^2$, in which $E =$ Elevation in inches of the outer rail at the gage line, $D =$ Degree of Curve, and $S =$ Velocity in miles per hour, will give essentially correct theoretical elevation for the outer rail of curves and is recommended for ordinary practice.	(a) Elevation of Curves: The approximate formula: $E = .00066\ DS^2$, in which $E =$ Elevation in inches of the outer rail at the gage line, $D =$ Degree of Curve, and $S =$ Speed in miles per hour, will give essentially correct theoretical elevations for the outer rail of curves, in which the resultant of forces passes practically through the center line of track.

Fourth Paragraph on Page 184

Present Form	*Proposed Form*
In general, in determining speed, consideration should be given to the traffic and the elevation fixed to give the greatest degree of economy in train operation.	In general, in determining speed for which a curve shall be elevated, it is necessary to consider traffic which includes moderately slow freight and relatively fast passenger trains. To secure economy in the operation of freight trains and comfort for passenger traffic, the selection of a speed in varying degrees less than the speed of the passenger trains over that particular curve is recommended.

Also the following addition to matter on page 184 of 1921 Manual is recommended:

> There will be found on page 899, Vol. 30 of the 1929 Proceedings a comparison in tabular form of curve elevations for equilibrium speed with "comfortable," "safe," and theoretical "overturning" speeds.

Last year the Committee recommended withdrawal of Classes "H" and "J" on plans No. 640, giving standard dimensions of self-guarded solid manganese steel frogs; No. 643 of No. 8 self-guarded solid manganese steel frogs; and No. 670 giving standard dimensions for solid manganese steel frogs, the lengths specified in these classes not permitting uniform tie spacing or any proper tie spacing. These three plans were previously adopted in March of 1927.

The Committee now presents revised tables for Classes "H" and "J" for self-guarded solid manganese frogs and for designs No. 1 and No. 2 solid manganese frogs to replace those withdrawn, and with this revision and other revisions for consistency with later plans, these plans (No. 640, No. 643 and No. 670), entitled and dated as noted below are offered for adoption as recommended practice and old plans of these numbers, adopted March, 1927, are recommended to be withdrawn from the Manual.

Plan No. 640, dated Revised Nov., 1928, A.R.E.A. standard dimensions for self-guarded frogs, solid manganese steel type.

Plan No. 643, dated Revised Nov., 1928, A.R.E.A. No. 8 self-guarded frog, solid manganese steel type.

Plan No. 670, dated Revised Nov., 1928, A.R.E.A. standard dimensions for solid manganese steel frogs.

Also the following revisions to plans to make them consistent with later plans are recommended:

Plans Nos. 301, 302, 303, 304, 306 and 309.

Add the following note:

"This plan applies in all details only to frogs for rails having combined width of head and base 8⅝ in. or less and for rails not lighter than 80 lb. per yard. For frogs for heavy rails see Plans Nos. 271 to 279, inclusive."

Plans Nos. 305 and 308.

Add the following note:

"Lengths shown on this plan apply only to frogs for rails having combined width of head and base 8⅝ in. or less. For frogs for heavy rails see Plans Nos. 271 to 279, inclusive."

Plans Nos. 320, 321 and 420.

Add the following note:

"Data shown on this plan apply only to frogs for rails having combined width of head and base 8⅝ in. or less. For frogs for heavy rails see Plans Nos. 271 to 279, inclusive."

Plans Nos. 401, 402 and 403.

Add the following note:

"This plan applies in all details only to frogs for rails having combined width of head and base 8⅝ in. or less and for rails not lighter than 80 lb. per yard. For frogs for heavy rails see Plans Nos. 271 to 279, inclusive."

Plan No. 404.

Add the following note:

"Length, tie spacing, and bolt spacing shown on this plan not applicable to frogs for rails having combined width of head and base exceeding 8⅝ in. For No. 10 spring rail frog for heavy rails see Plan No. 277."

Plans Nos. 601, 602, 603, 604, 605 and 609.

Add the following note:

"Lengths shown on this plan apply only to frogs for rails having combined width of head and base 8⅝ in. or less. For frogs for heavy rails see Plans No. 273 to 279, inclusive."

Plan No. 608.

Add the following note:

"Lengths shown on this plan apply only to frogs for rails having combined width of head and base 8⅝ in. or less. For frogs for heavy rails see Plans Nos. 271 and 272."

Plans Nos. 651, 652, 653, 654, 655 and 656.

Add the following note:

"For heavy rail data and additional options see Plan No. 670, revised November, 1928; also disregard tabulated heights and widths designated as 'Casting Data.'"

Also add the following note:

"This plan applies in all details only to frogs for rails having combined width of head and base 8⅝ in. or less. For dimensions and tie layouts for frogs for heavy rails see Plans Nos. 271 to 279, inclusive."

Revisions to Specifications for Switches, Frogs, Crossings and Guard Rails, as follows, are also recommended:

Section 38

Present Form

"38. Fit of Bolts. Main or body bolts in bolted rigid frogs and bolted rail crossings shall have a tight fit in straight, true holes. Heads and nuts shall have a square bearing. Other bolts not requiring a tight fit, unless otherwise specified, shall have a clearance of not more than $\frac{1}{16}$ in. in drilled or punched holes and not more than ⅛ in. in cored holes. Threads must be U.S. standard, accurately cut within tolerance of best practice for cut threads. Nuts must have a tight fit."

Proposed Form

"38. Fit of Bolts. Main bolts (also referred to on plans as 'through' or 'body' bolts) in bolted rigid frogs and bolted rail crossings shall have a tight fit in straight, true holes. Heads and nuts shall have a square bearing. Other bolts not requiring a tight fit, unless otherwise specified, shall have a clearance of not more than $\frac{1}{16}$ in. in drilled or punched holes and not more than ⅛ in. in cored holes. Holes in solid manganese steel frogs and crossings to be ¼ in. larger than bolt diameter as specified on plans. Threads must be U.S. standard, accurately cut within tolerance of best practice for cut threads. Nuts must have a tight fit."

The Committee also recommends withdrawal of Index pages I, II, III and IV, dated March, 1928, and substitution of revised Index, dated March, 1929, pages I, II, III and IV, listing plans and specifications, and pages V and VI, listing changes in old plans and specifications recommended above, also changes adopted in March of 1927 and March, 1928, not yet inscribed on old plans or specifications affected.

Appendix B

(2) MAKE CRITICAL REVIEW OF THE MATERIAL NOW APPEARING IN PUBLICATIONS OF THE ASSOCIATION RELATING TO CURVE ELEVATION; ASCERTAIN EXISTING VIEWS AND PRACTICES OF THE RAILWAYS; AND RECOMMEND SUCH CHANGES AS ARE FOUND DESIRABLE

C. W. Breed, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, J. B. Akers, W. G. Arn, W. H. Bevan, H. R. Clarke, J. M. Fair, C. J. Geyer, F. S. Hales, E. T. Howson, H. D. Knecht, C. M. McVay, J. B. Myers, C. R. Strattman, T. P. Warren, J. R. Watt.

(1) CONTINUE CRITICAL REVIEW OF MATERIAL NOW APPEARING IN PUBLICATIONS OF THE ASSOCIATION

After careful consideration and review of all material appearing in the publications of the Association relative to curve elevation, this Committee is of the opinion that all data required by an Engineer to decide the proper amount of elevation for the outer rail of curves is contained therein.

The report of the Special Committee, consisting of F. S. Stevens and G. J. Ray, appearing in Vol. 15, Proceedings of the 15th Annual Convention in 1914, in particular, contains complete information.

(2) ASCERTAIN EXISTING VIEWS AND PRACTICES OF THE RAILWAYS

In the Proceedings of the First Annual Convention of the Association in 1900, the Track Committee reported:

> "The elevation of curves should be governed primarily by the speed of trains passing over them; but as the speed varies greatly with the same train in different places, and still more with different classes of trains, it necessarily follows that no rule can be laid down for the elevation of any degree of curve at all localities, but each case must be judged by itself."

Having in mind the variances from the equilibrium table which this statement would lead us to expect, the Committee corresponded with the Engineering Department of 53 representative railways to learn their present views and practices in their respective territories, and under a variety of conditions.

The replies which follow indicate that those companies which have tracks given over exclusively to passenger traffic, elevate curves in such tracks, in general, for equilibrium speed.

On other railways where passenger traffic is relatively unimportant and freight traffic heavy, curves are elevated to favor speed of freight trains, and the speed of passenger trains is reduced to point where comfort of passengers is assured.

On those railways where both passenger and freight traffic is heavy, the speed for which curves are elevated is necessarily a compromise, the comfort of passengers being the deciding factor.

These replies, in addition to present views and practice, give a great deal of workable information relative to curve elevation.

Atchison, Topeka & Santa Fe—G. W. Harris, Chief Engineer, System

Our curve elevation table agrees with the present table in the Manual, and therefore I am not furnishing you with a copy of same.

Our maximum superelevation allowed is six inches.

This table is not followed absolutely in elevating curves in all cases, but as near as practicable. The amount of superelevation is governed to a large extent by the average speed of our passenger trains and also by consideration being taken of the speed, number and importance of our freight trains. The actual speed to be used is determined by the Assistant General Manager, District Engineer and Superintendent, who investigate the traffic and determine the speed that should be used to secure the best handling of traffic.

Atlantic Coast Line—J. E. Willoughby, Chief Engineer

Most of the curvature on the Atlantic Coast Line tracks is light. Our usual practice is to elevate the outer rail one inch for each degree of curvature, with six inches as the maximum elevation of the outer rail.

Baltimore & Ohio—Earl Stimson, Chief Engineer Maintenance

There is attached copy of the "Curve Superelevation Table" used on the Baltimore and Ohio Railroad. Information governing its use is also given. (See A).

It is the policy of the Company to superelevate for the fastest trains. The exception permissible is where passenger traffic is unimportant and freight traffic heavy; advantage is not to be taken of this exception in any case where comfort of passenger patrons is involved.

Speed restrictions, corresponding to the speed for which the curve is superelevated, are established, and no trains are allowed any speed in excess of those restrictions.

All practical purposes are served by the table of superelevations now in the Manual. Unbalanced superelevations should be exceptions to be dealt with by each of the railroads for any of their special conditions where considered justifiable. The amount of such unbalancing should also be subject of their special determinations. The Manual table should not include them, though it is suggested that the bases and the formula for their establishment are subject matter of value to members, to which reference may be had in the Proceedings.

The following table of superelevation is to be used, selecting the elevation to conform to the speed of trains over the curve under consideration. On double track, care should be taken to ascertain the speed on each track, as on grades there is usually a considerable difference. Ordinarily it is proper to elevate the track to suit the passenger train speed. On lines of excessive freight traffic and unimportant passenger traffic, the elevation adopted should be compromised to suit as nearly as may be, both classes of traffic. Standard elevation marks must be placed as per the standard plans.

Curve Superelevation Table

Superelevation of Outer Rail in Inches. Corresponding to Speed in Miles per Hour

Deg. of Curve	10	15	20	25	30	35	40	45	50	55	60	65
0° 30'	0"	0"	0"	0"	¼"	¼"	½"	½"	¾"	1"	1"	1¼"
1° 00'	0"	0"	¼"	¼"	½"	¾"	1"	1¼"	1½"	2"	2¼"	2¾"
1° 30'	0"	0"	¼"	½"	¾"	1"	1½"	2"	2½"	3"	3½"	4¼"
2° 00'	0"	¼"	½"	½"	1"	1½"	2"	2½"	3¼"	4"	4¾"	5½"
2° 30'	0"	¼"	½"	1"	1½"	2"	2½"	3¼"	4"	5"	6"	7"
3° 00'	0"	¼"	¾"	1¼"	1¾"	2¼"	3"	4"	5"	6"	7"	-
3° 30'	¼"	½"	¾"	1¼"	2"	2¾"	3½"	4½"	5¾"	7"	-	-
4° 00'	¼"	½"	1"	1½"	2¼"	3¼"	4"	5¼"	6½"	-	-	-
4° 30'	¼"	½"	1"	1¾"	2½"	3½"	4½"	6"	7¼"	-	-	-
5° 00'	¼"	¾"	1¼"	2"	3"	4"	5"	6½"	-	-	-	-
5° 30'	¼"	¾"	1¼"	2¼"	3¼"	4½"	5½"	7"	-	-	-	-
6° 00'	¼"	¾"	1½"	2½"	3½"	4¾"	6"	7½"	-	-	-	-
6° 30'	¼"	1"	1¾"	2½"	3¾"	5¼"	6½"	-	-	-	-	-
7° 00'	¼"	1"	1¾"	2¾"	4"	5½"	7"	-	-	-	-	-
7° 30'	½"	1"	2"	3"	4½"	6"	7½"	-	-	-	-	-
8° 00'	½"	1"	2"	3¼"	4¾"	6½"	-	-	-	-	-	-
8° 30'	½"	1¼"	2¼"	3½"	5"	6¾"	-	-	-	-	-	-
9° 00'	½"	1¼"	2¼"	3¾"	5¼"	7"	-	-	-	-	-	-
9° 30'	½"	1½"	2½"	3¾"	6½"	7½"	-	-	-	-	-	-
10° 00'	½"	1½"	2½"	4"	6"	-	-	-	-	-	-	-
10° 30'	¾"	1½"	2¾"	4¼"	6¼"	-	-	-	-	-	-	-
11° 00'	¾"	1½"	2¾"	4½"	6½"	-	-	-	-	-	-	-
11° 30'	¾"	1½"	3"	4¾"	6¾"	-	-	-	-	-	-	-
12° 00'	¾"	1¾"	3"	5"	7"	-	-	-	-	-	-	-
13° 00'	¾"	1¾"	3½"	5¼"	-	-	-	-	-	-	-	-
14° 00'	¾"	2"	3¾"	5¾"	-	-	-	-	-	-	-	-
15° 00'	1"	2¼"	4"	-	-	-	-	-	-	-	-	-
16° 00'	1"	2¼"	4¼"	-	-	-	-	-	-	-	-	-
18° 00'	1"	2½"	4¾"	-	-	-	-	-	-	-	-	-
20° 00'	1¼"	3"	-	-	-	-	-	-	-	-	-	-

Boston & Maine—W. F. Cummings, Engineer Maintenance of Way

We have endeavored to use the curve elevation table of the 1921 A.R.E.A. Manual modified to fit the conditions. The conditions governing being grades coupled with the composite speed of the traffic on various degrees of curves.

It is our endeavor not to exceed the maximum safe speed, which, of course, is variable depending on the degree of curve and the elevation over the equilibrium speed.

Buffalo, Rochester & Pittsburgh—E. F. Robinson, Chief Engineer

We do not have a curve elevation table as such. It is our practice to fix the elevation for each curve to meet the conditions applying to that particular curve. It is our usual rule, modified as may be necessary, to elevate curves at the rate of three-fourths of an inch, one-inch or one and one-fourth-inch per degree, depending upon conditions. In this connection, all curves on our main tracks and branches are eased or spiralled.

The proper elevation to apply to each curve is the subject of conference between the Chief Engineer, Engineer Maintenance of Way and division officers. The elevation for each curve is then established. Division officers and track foremen are furnished a blue print record in pocket form, showing the location of curves, degree of curves and the elevation to apply to each curve. For your information, I am sending to you, under separate cover, curve elevation diagram covering our main line between Rochester,

N. Y., and Ashford, N. Y., also curve elevation diagram covering our double track main line between Clarion Junction, Pa., and Indiana Junction, Pa., including our Clearfield and Mahoning Branch. These diagrams cover only a part of our road, but will be sufficient to indicate our practice.

It is our practice to place standard elevation posts showing zero and full elevation on all curves three (3) degrees and over.

On account of our heavy freight traffic, comparatively heavy grades and severe curvature, it is not always possible to elevate curves for high speed passenger trains, but as stated above the elevation of each curve is established to meet local conditions. Under our practice, a six-degree curve elevated at the rate of one inch per degree, where local conditions and freight traffic will permit of such elevation, will have an elevation of six inches, which we consider absolutely safe for a speed of fifty miles per hour. This compares with fifty-four miles per hour maximum safe elevation shown in Table "B."

In locations where the freight traffic and grades are such that maximum elevation for high speed passenger trains can not be provided, the speed of such trains is restricted by bulletin, by practice, or by instructions.

The maximum elevation we permit in any case is six and one-half inches. The speed of trains is reduced to conform to this maximum elevation. It is the practice to require engineers of passenger trains to reduce speed in entering all high degree curves.

Canadian National—T. T. Irving, Chief Engineer

Our curves are elevated to suit our most important passenger trains, which are the fastest trains operated over them.

The elevation of outer rail on curves is adapted to the speed of all classes of trains which pass over them, with due regard for comfort of passengers, safety of trains and economy in track maintenance.

The elevation of outer rail does not exceed six inches.

On sharp curves in yards, wye tracks or other sidings where the speed of trains is generally never in excess of ten miles per hour, the outer rail is not elevated, but both rails maintained level.

The following table gives the theoretical elevations for trains traveling in one direction, and is used only as a guide to the study of special conditions. On single track territory where trains travel in both directions, special care is taken in arriving at the elevation of outer rail for curves which are on grades where trains traveling down grade will have a low speed, and also at places where there are both fast and slow trains.

If, after having elevated the outer rail, the relative wear of rails indicates too much or too little elevation, the necessary adjustment in elevation for speed of trains is promptly made.

Elevation Table

Degree of Curve	Rate of speed in miles per hour										
	10	15	20	25	30	35	40	45	50	55	60
1	0	0	½	½	½	1	1	1½	1½	2	2½
2	0	0	½	1	1	1½	2	2½	3	4	5
3	0	½	1	1½	2	2½	3	4	5	5½	6
4	0	½	1	2	2½	3	4	5	6		
5	½	1	1½	2	3	4	5	6			
6	½	1	1½	2½	3½	5	6				
7	½	1	2	3	4	5½					
8	½	1	2	3½	4½	6					
9	½	1½	2½	4	5½						
10	1	1½	2½	4	6						
11	1	2	3	4½							
12	1	2	3	5							
15	1	2½	4	6							

Canadian Pacific—J. M. R. Fairbairn, Chief Engineer

Permissible limit of speed beyond that for which a curve is elevated has not been fixed, but in certain cases where high loads, such as pulp wood, are moved at low speeds, and consequently curves have been elevated materially less than is provided for in our elevation table, permanent slow orders for all trains have been issued and permanent slow signs erected.

The elevation of outer rail on curves is adapted to the speed of all classes of trains which pass over them, with due regard for comfort, safety and economy in track maintenance.

The elevation on single track does not exceed 6 inches. On maximum grades, track on curves exceeding 6 degrees is in no case elevated more than 4½ inches in order to avoid tendency of derailment of the slow trains. On minor grades, superelevation on curves exceeding 6 degrees must receive special consideration.

If, after having elevated the outer rail according to table, the relative wear of rails indicates too much or too little elevation, the necessary adjustment in elevation or speed of trains is promptly made.

Uniformity of elevation is far more important than the exact amount of elevation.

Elevation Table

Degree of Curve	Rate of Speed in Miles per Hour								
	15	20	25	30	35	40	45	50	60
1	½	½	½	½	1	1	1¼	1½	2
2	½	½	1	1	1½	2	2½	3	4
3	½	1	1	2	2½	3	4	4½	6
4	1	1	1½	2½	3	4	5	6	
5	1	1½	2	3	4	5	6		
6	1	1½	2½	3½	5	6			
7	1	2	3	4	5½				
8	1	2	3½	5	6				
9	1½	2½	4	5½					
10	1½	2½	4½	6					
12	2	3	5						
15	2½	4	6						

Central of Georgia—C. E. Weaver, Chief Engineer

I would say that, in general, our fastest passenger trains, particularly on heavy grades, make 15 miles per hour more than the speed which corresponds with the elevation shown in the table. In other words, while we do not change the restriction of speed of passenger trains over the division on account of grades and ordinary curves, we are obliged to make a compromise elevation which will accommodate the freight traffic in the opposite direction, and, in cases of this kind, it appears that our practice is not far from the values shown under your Table "C" in your attachment "B." You understand that I am now speaking of single track operation.

I believe that the curve elevation table is, at the best, only a guide, as there are so many factors which affect the question of proper elevation that good judgment in the end will have to prevail, and that is the basis of the first part of our Rule No. 318, to which I have already referred. On some roads double-track passenger tracks are in service; on many other roads there are double tracks for passenger and freight service combined. On still a greater proportion of mileage, there is single track for passenger and freight train operation, which involves maximum passenger train speed allowed in one direction and the slowest possible freight train speed in the opposite direction.

"318. Elevation.—The outer rail of curves will be given such elevation as the Supervisor directs, the amount to be governed by the location with reference to speed, grades and other conditions. Wherever it is practicable the full elevation should be given throughout the entire length of simple curves, and the run-off made on the tangents at the rate of ½ inch of elevation for each 33 feet of distance. On spiralled curves the track must be level at the point of spiral, and the elevation brought up regularly in the length of the spiral to full elevation at the point where the main curve begins.

"320. Table of Elevations.—The elevation of the outer rail on curves must be the number of inches given in the following table, unless local conditions require a modification:

Elevation Table

Degree of Curve	Speed in Miles per hour								
	20	25	30	35	40	45	50	55	60
1	1/2	1/2	1/2	3/4	1	1	1	1	1 1/4
2	3/4	3/4	1	1 1/2	2	2	2	2 1/4	2 1/2
3	1 1/4	1 1/4	1 3/4	2 1/4	3	3	3 1/4	3 1/2	3 3/4
4	2	2	2 1/2	3	4	4 1/4	4 1/2	4 3/4	5
5	2 1/2	2 3/4	3 1/2	4	5	5 1/2	5 3/4	6	6 1/4
6	3	3 1/2	4 1/2	5	6	6 1/4	7	7	7
7	3 1/2	4 1/2	5	6	6	7			
8	4	4 1/2	5	6					

(The elevation of curves must not exceed 7 inches without special instructions).

Central of New Jersey—A. E. Owen, Chief Engineer

Our rule covering the elevation of outer rail on curves reads:

On straight lines rails must be laid on the same level except on approaches to curves, on curves the proper elevation must be given to outer rail. Superelevation of outer rail of curves in main track to be the middle ordinate in inches of a chord equal in length to the distance run per second by the average express trains, in appendix, but elevation in no case to exceed 8 inches.

Elevation to be run out one-half inch to each thirty-foot rail where practicable.

"The track level must be used when surfacing track, and be tested each day before being used; same end must be used on same rail."

Superelevation

D	Velocity in Miles per Hour											
	10	20	30	35	40	45	50	55	60	65	70	75
1	.004	.018	.042	.056	.075	.095	.117	.142	.168	.199	.230	.263
2	.009	.037	.084	.114	.150	.189	.234	.283	.337	.395	.459	.527
3	.014	.056	.126	.172	.225	.284	.351	.425	.506	.594	.690	.791
4	.019	.075	.169	.228	.300	.380	.469	.568	.675	.793	.920	
5	.023	.094	.211	.287	.375	.475	.585	.710	.845	.991		
6	.028	.112	.253	.344	.450	.570	.703	.851				
7	.032	.130	.295	.401	.525	.663	.820	.992				
8	.038	.150	.338	.460	.601	.760	.939					
10	.046	.188	.422	.575	.751	.950						
12	.057	.226	.507	.690	.901							
14	.066	.262	.590	.804								
16	.075	.301	.674	.918								

We have no fixed rule giving the speed in excess of that shown in the table that is permitted. Our time table limits speed on various curves and, generally speaking, our practice is comparable with your table "B" in that Central Railroad limits lie within the equilibrium speed and comfortable speed. Generally our speeds for the same degree of curve and same elevation as that shown on your table "B" are below the suggested figure.

Chesapeake & Ohio—C. J. Geyer, Engineer Maintenance of Way

I am attaching blueprint of standard drawing MW 169 showing the standard method for superelevation of curves on the Chesapeake & Ohio. This superelevation table carries the same elevations as shown on page 184 of the 1921 A.R.E.A. Manual for superelevation of curves.

It is the practice on this railroad in applying the superelevation shown in this table, to determine the average speed for all trains on each individual curve and apply the elevation for this speed according to the table. We permit speed in excess of this average to about that speed shown as the comfortable speed on your Attachment B.

Chicago & Alton—R. A. Cook, Chief Engineer

With respect to the superelevation of the outer rail on curves, I am forwarding you herewith a blue print of our Plan No. 11035 giving the superelevations for various curves and various speeds. This, however, is the same thing as the table appearing on page 184 of the 1921 Manual. I have one criticism to make of this table, which is that it gives the difference in elevation of the two rails at the gage lines. I think, to be strictly correct, it should give the superelevation between the two points, one on each rail of the track, which are most likely to be used by a section foreman in determining the superelevation with a track level. I am under the impression that this is more likely to be the distance between the vertical center lines of the two rails than the distance between the two gage lines of the two rails. The Manual states that the superelevation equals $.00066\ DS^2$. This formula, I understand, involves using the gage of track. If the distance between the vertical center lines of the two rails is used, however, I understand this formula will be E equals $.000689\ DS^2$.

Regarding the speed for which curves are elevated, on ordinary degrees of curvature, which is 4 degrees or less, where passenger trains make high rates of speed, a speed of 50 miles per hour is used. For higher degrees of curvature or where some local condition limits the speed of trains a less speed is used according to circumstances.

Chicago & Eastern Illinois—L. C. Hartley, Chief Engineer

We are elevating the outer rail on curves in accordance with the table adopted by the A.R.E.A. with the exception that we elevate to the nearest ¼ inch instead of the nearest ⅛ inch, as I believe this is close enough to work.

We, of course, modify the superelevation to meet certain conditions such as grades on single track, but keep the elevation within the limits of comfortable speed.

Chicago, Burlington & Quincy—A. W. Newton, Chief Engineer

The Burlington table of curve elevations is the same as that printed in the A.R.E.A. Manual.

The elevations for various speeds of trains, as set forth in A.R.E.A. Manual, are the results of much study as well as of actual experience, and for the given speeds may be considered as being adapted to not only comfort for those riding passenger trains, but also to economic maintenance and operating requirements.

Local conditions may and frequently do require deviation from the prescribed elevation, and on the Burlington these deviations are at the discretion of local operating officers, who are also responsible for maintenance, and operation—which latter includes control of speed of trains.

Chicago Great Western—C. G. Delo, Chief Engineer

"Herewith blueprint copy of our elevation table:

Mi. per Hour	0°15'	0°30'	0°45'	1°0'	1°30'	2°0'	2°30'	3°0'	3°30'	4°0'
20	1/8"	1/8"	1/4"	1/4"	1/2"	5/8"	3/4"	3/4"	1"	1"
30	1/4"	1/4"	3/8"	1/2"	1	1 1/4	1 1/2	1 3/4	2	2 1/2
40	3/8	1/2	3/4	1	1 1/2	2	2 3/4	3 1/4	3 1/2	4 1/4
50	1/2	3/4	1 1/4	1 1/2	2 3/8	3 1/4	4 1/4	5	5 3/4	6
60	5/8	1 1/4	1 3/4	2 1/4	3 1/2	4 3/4	6	6	6	
70	3/4	1 3/4	2 1/2	3 1/4	4 3/4	6	6			

Mi. per Hour	4°30'	5°0'	5°30'	6°0'	7°0'	8°0'	9°0'	10°0'	11°0'	12°0'
20	1 1/4"	1 1/4"	1 1/2"	1 1/2"	1 3/4"	2"	2 1/4"	2 3/4"	3"	3 1/4"
30	2 3/4	3	3 1/4	3 1/2	4 1/4	4 3/4	5 1/4	6	6	6
40	4 3/4	5 1/4	5 3/4	6	6	6	6	6		
50	6	6	6							
60										
70										

The elevation of outer rail on curves begins at point of spiral where it is zero and increases directly in proportion to the distance until the end of spiral or beginning of simple curve is reached, where it is a maximum and continues at the same superelevation throughout the simple curve.

A speed of 25 per cent in excess of that corresponding to any specific elevation will be permitted. The maximum superelevation of outer rail on any curve is 6 inches.

You will note that we limit our superelevation to six inches. Our curves are not elevated for our fastest trains but we permit, as you will note, an increase of 25 per cent in speed over and above that for which the curve is superelevated.

Chicago, Milwaukee, St. Paul & Pacific—W. H. Penfield, Engineer Maintenance of Way

We are using a formula for superelevating our curves which is an old one and which has apparently worked very well for our requirements: "Elevation in inches equals square of speed in miles per hour multiplied by degree of curve divided by 1800," or $E = \frac{D V^2}{1800}$.

We endeavor to keep our superelevation down to a maximum of three inches wherever practicable, although we do carry elevation on some of our more important lines as much as 4½ inches.

At one time we carried excessive superelevation on many of our lines where we had a few fast passenger trains and many heavy-drag freight trains. We had frequent derailments and trouble in maintaining the curves, also wore out the rail much more rapidly. We find generally for a six-degree curve that we can take care of speeds of 40 miles per hour very nicely without uncomfortable riding, and that this three inches superelevation is not burdensome to the drag freight trains.

Chicago & North Western—C. T. Dike, Engineer of Maintenance

Attached hereto is sheet from our book of standards upon which we give the elevation of the outer rail for the balanced speed, together with the instructions for the application of this.

You will notice we attempt to get our elevation so that it will not differ more than 1½ inches either way from the speed of the fastest and slowest trains.

On railroads having curvatures such as is generally found in this part of the country a 1½-inch leeway either way from the balanced speed, curvature and elevation seems to be ample.

Inasmuch as the A.R.E.A. table is one to which engineers who understand the theoretical basis will refer, it seems to me that there should be in this table also a line for slow or freight train speed corresponding to equilibrium at, say, one-half the actual elevation.

Elevation of Outer Rail on Curves in Inches to Theoretically Balance Speed and Curvature

Deg. of Curve	Speed in Miles per Hour										
	10	15	20	25	30	35	40	45	50	55	60
1	0	1/8	1/4	3/8	5/8	3/4	1-1/8	1-3/8	1-5/8	2	2-3/8
2	1/8	3/8	1/2	7/8	1-1/8	1-5/8	2-1/8	2-5/8	3-1/4	4	4-1/4
3	1/4	1/2	3/4	1-1/4	1-3/4	2-3/8	3-1/8	4	4-7/8	6	7-1/8
4	1/4	5/8	1	1-5/8	2-3/8	3-1/4	4-1/4	5-3/8	6-5/8	8	9-1/2
5	3/8	3/4	1-1/4	2	3	4	5-1/4	6-5/8	8-1/4		
6	3/8	1	1-5/8	2-1/2	3-1/2	4-7/8	6-1/4	8			
7	1/2	1-1/8	1-7/8	2-7/8	4-1/8	5-5/8	7-3/8				
8	1/2	1-1/4	2-1/8	3-1/4	4-3/4	6-1/2	8-3/8				
9	5/8	1-3/8	2-5/8	3-3/4	5-3/8	7-1/4					
10	3/4	1-1/2	2-5/8	4-1/8	5-7/8	8-1/8					

Note: A maximum elevation of 6 inches should not be exceeded and speed of trains regulated accordingly.

General Notes.—The object of superelevation is to counterbalance the effect of centrifugal force so that the load may be as near as possible the same on each rail. The above tabulation is theoretically correct for uniform speeds but as in most cases speeds will not be uniform, the elevation must be adjusted to suit conditions. Superelevation differing by from an inch to one and one-half inches from that which theoretically balances the curvature and speed is usual and permissible. This allowable inequality of theoretical balance overloads neither the outside nor inside rails. Where possible, the full elevation should be maintained throughout simple curve or throughout the sharper portion of compound curve. In running off elevation use, if practicable, for each ½-inch reduction, a distance measured in feet equal to speed of train. For example: Speed 40 miles per hour, reduction ½ inch in 40 feet.

The difficulty with tables of elevation as now published in handbooks and frequently quoted in catalogues is that such tables are never accompanied by any notation as to what is permissible variation from the speed, elevation and curvature indicated. One of the results of this is that elevation is frequently put on the track such as to be in equilibrium for the fastest train, thus considerably exceeding the proper elevation and causing unnecessary wear on the inner rail. Therefore, any table such as that indicated on Attachment A should have a note thereon indicating a practical variation from the exact balance indicated by the table. We believe we have accomplished this in the instructions applying to our table in which we state that superelevation differing from an inch to one and one-half inches from equilibrium is permissible. There could be added to this statement that 3-inch variation is not objectionable.

Chicago, Rock Island & Pacific Ry.—C. A. Morse, Chief Engineer

On the Rock Island we use the A.R.E.A. table for elevation of the outer rail on curves, and we give the following instructions in connection with its use:

Do not use any elevation greater than 8 inches. Be governed by the location of the curve as to rate of speed of passenger trains. Make full elevation at beginning and ending of main curve. On curves of less than 2 degrees make the run off at each end of curve 30 feet for each ½ inch of elevation of curve. On reverse curves, make the track level on point of reverse and get full elevation by running each way 30 feet for each ½ inch elevation.

We have a general rule to the effect that the elevation of curves shall be for 10 miles an hour less than the maximum speed of passenger trains over that curve. This for the reason that a high elevation on outer rail of curves on track that is used by both passenger and freight trains, especially on maximum grade, makes a hard pull for a freight train, and in addition to this the extra amount of weight thrown on the inner rail by the heavy freight trains causes a very rapid deterioration of the inside rail on curves.

Denver & Rio Grande Western—A. C. Shields, General Manager

Herewith a table which I have prepared since coming to this line, which has worked out very satisfactorily. Our curves are elevated for our fastest trains, but we allow a variation of 5 miles per hour.

Tabulation showing superelevation to be used on curves where there are no speed restrictions less than that shown in this tabulation account grade or other conditions.

Degree of Curve	Elevation	Maximum Speed
1	1-3/8 inches	50 M.P.H.
2	2-5/8 "	50 "
3	4	50 "
4	5	50 "
5	5	45 "
6	5	40 "
7	5	35 "
8	5	35 "
9	5	30 "
10	5	30 "
11	5	25 "
12	5	25 "
13	4	20 "
14	4	20 "

"In the event that speed is restricted lower than that shown in above table be governed by the theoretical elevation."

In my opinion the table that now appears in the 1921 A.R.E.A. Manual gives an elevation greater than is actually required for comfortable and safe riding.

Florida East Coast—W. G. Brown, Engineer Maintenance of Way

Until about 1923 or 1924, the 1921 A.R.E.A. Manual's elevation table was generally followed. At that time rail wear indicated that the prescribed elevations were excessive for our traffic and operating conditions, and we began to elevate outer rails to best suit local conditions, as determined by observation and experience. This resulted generally, in a rough way, of from 1¼-inch to 1⅜-inch per degree of curvature, approximating the comfortable speed elevation figures based upon the equilibrium table shown in the 1921 Manual. We elevate from experience and actual observation of conditions.

Great Northern Ry—J. R. W. Davis, Chief Engineer

On the Great Northern it is the practice to elevate for a speed five miles to ten miles per hour less than that which is normal for passenger trains, the excess centrifugal force resulting from this deficiency in elevation holding the equipment to the outside rail, with the result that there is less jolting of car and more comfort for the passengers. Elevations begin with ¼ inch and increase by ¼ inch intervals to 4½ inches, the maximum. Rather than exceed 4½ inches speed is reduced.

To show elevations at intervals of 1/8 inch is, we believe, a refinement, something that cannot be, and need not be, worked to in practice.

Elevation of outer rail in curves of side tracks seldom exceeds 1 inch, irrespective of curvature, and varies from nothing for light curves to 1 inch for the very sharp curves.

We do not use an elevation table, but instead furnish a curve book in which is shown the elevation and the length of easement for each curve. Leaf from one of these books is attached. On the ground each curve is marked with a number board and with superelevation boards that mark the beginning and the termination of the elevation, and of the easement curve which corresponds in length to the run-off in elevation. These boards are placed at compounds as well as at ends of curve.

For lines handling mixed traffic—both freight and passenger—I doubt the advisability of using elevations in excess of 5 inches.

In general, it is our practice to elevate curves 1/16 inch per degree, per ten miles of speed, elevation varying directly with the curvature and directly with square of speed. For example, a four-degree curve set up for a speed of forty miles per hour would have an elevation 1/16 inch by 4 by 16, equal to four inches.

Curves over which speed is restricted are marked by speed restriction boards placed far enough in advance of curve to enable engineer to comply with speed restriction.

SPOKANE DIVISION — WENATCHEE - OROVILLE LINE — VAL. SEC. 806

LOCATION	CURVE NO.	DEGREE OF CURVE	DIRECTION OF CURVE GOING WEST	LENGTH OF CURVE	LENGTH OF EASEMENT WEST END	LENGTH OF EASEMENT EAST END	ELEV. OF OUTER RAIL IN INCHES	REMARKS
WENATCHEE								
		4°20'	RIGHT	179'	20'	140'	2½"	
	1	3°45'	RIGHT	439'	55'	20'	2¼"	COMPOUND CURVE
		5°00'	RIGHT	237'	125'	55'	3"	125' SPIRAL-WEST END
	2	3°00'	RIGHT	1000'	150'	150'	2"	150' SPIRAL-EACH END
OLDS								
	3	2°00'	LEFT	1208'	100'	100'	1½"	100' " "
	4	1°00'	LEFT	675'	70'	70'	1"	
	5	0°30'	RIGHT	327'	30'	30'	¼"	
	6	1°00	LEFT	620'	55'	55'	¾"	
	7	2°30'	RIGHT	680'	125'	125'	2"	125' SPIRAL-EACH END
	8	4°00	LEFT	680'	200'	200'	3"	200' " "

Illinois Central System—L. H. Bond, Engineer Maintenance of Way

The table shown on page 90 of the Illinois Central rules, dated September 1, 1926, follow closely the A.R.E.A. recommendations except that the elevation is slightly less in each case, representing about a reduction of five miles per hour. The figures given in the table are from practice and I believe do not conform exactly to the figures used by other roads. Curves are elevated for fastest trains or the speed of the train is restricted to correspond with the curvature.

TABLE OF ELEVATIONS.—The elevation of the outer rail on curves must be the number of inches given in the following table unless local conditions require a modification:

Degree of Curve	15	20	25	30	35	40	45	50	55	60	65
	Speed in Miles per Hour										
0° 30'			1/8	1/8	1/4	3/8	1/2	3/4	7/8	1	1-1/8
1 0'	1/8	1/8	1/4	3/8	5/8	3/4	1-1/8	1-3/8	1-5/8	2	2-3/8
2 0'	1/8	1/4	1/2	7/8	1-1/8	1-5/8	2-1/8	2-5/8	3-1/4	4	4-3/4
3 0'	1/4	3/8	3/4	1-1/4	1-3/4	2-3/8	3-1/8	4	4-7/8	6	7-1/8
4 0'	1/4	1/2	1	1-5/8	2-3/8	3-1/4	4-1/4	5-3/8	6-5/8	8	
5 0'	3/8	5/8	1-1/4	2	3	4	5-1/4	6-5/8			
6 0'	3/8	3/4	1-1/2	2-1/2	3-1/2	4-7/8	6-1/4				
7 0'	1/2	7/8	1-3/4	2-7/8	4-1/8	5-5/8	7-3/8				
8 0'	1/2	1	2	3-1/4	4-3/4	6-1/2					
9 0'	5/8	1-1/8	2-1/4	3-3/4	5-3/8	7-1/4					
10 0'	5/8	1-1/4	2-1/2	4-1/8	5-7/8						
11 0'	3/4	1-3/8	2-3/4	4-1/2	6-1/2						
12 0'	3/4	1-1/2	3	4-7/8	7-1/8						

(The elevation of curves must not exceed 6 inches without special instructions).

(The elevation of curves must not exceed 6 inches without special instructions.)

Kansas City Southern—A. N. Reece, Chief Engineer

Attached is print of tabulation of curve elevations which we have prepared. This is used for information only and we do not adhere strictly to it in determining our curve elevations.

Due to the fact that we handle our freight movement in heavy trains with large locomotives, and that our passenger traffic does not constitute a large proportion of our business, we do not elevate our sharper curves for equilibrium speed for passenger trains. The maximum elevations used is six inches. The speed of all trains is restricted by time card and slow boards to a point well below the "comfortable speed" or speed for an unbalanced elevation of 3 inches.

SUPERELEVATION OF CURVES FOR VARIOUS COMBINATIONS OF FREIGHT AND PASSENGER TRAIN SPEEDS

Curvature	Speeds M.P.H. Frt. 20 Pass. 35			Speeds M.P.H. Frt. 20 Pass. 45			Speeds M.P.H. Frt. 25 Pass.45		
	Elev. Frt.	Elev. Pass.	Av. Elev.	Elev. Frt.	Elev. Pass.	Av. Elev.	Elev. Frt.	Elev. Pass.	Av. Elev.
0° 30'	1/8"	3/8"	1/4"	1/8"	11/16	1/2"	3/16"	11/16"	1/2"
1° 00'	1/4"	13/16	1/2	1/4	1-5/16	3/4	7/16	1-5/16	1
1° 30'	3/8"	1-3/16	3/4	3/8	2	1¼	5/8	2	1¼
2° 00'	1/2	1-5/8	1	1/2	2-11/16	1½	13/16	2-11/16	1¾
2° 30'	11/16	2	1¼	11/16	3-5/16	2	1	3-5/16	2⅛
3° 00'	13/16	2-7/16	1½	13/16	4	2½	1¼	4	2½
3° 30'	15/16	2-13/16	2	15/16	4-11/16	2¾	1-7/16	4-11/16	3
4° 00'	1-1/16	3¼	2½	1-1/16	5-5/16	3¼	1-5/8	5-5/16	3½
4° 30'	1-3/16	3-5/8	2½	1-3/16	6	3½	1-7/8	6	4
5° 00'	1-5/16	4-1/16	2¾	1-5/16	*6	#4	2-1/16	*6	#4½
5° 30'	1-7/16	4-7/16	3	1-7/16	*6	#4½	2¼	*6	#4¾
6° 00'	1-9/16	4-7/8	3¼	1-9/16	*6	#4¾	2½	*6	#5¼
6° 30'	1-11/16	5¼	3½	1-11/16	*6	#5¼	2-11/16	*6	#5¾
7° 00'	1-7/8	5-5/8	3¾	1-7/8	*6	#5¾			x
7° 30'	2	*6	#4	2	*6	#6			
8° 00'	2-1/8	*6	#4½			x			

SUPERELEVATION OF CURVES FOR VARIOUS COMBINATIONS OF FREIGHT AND PASSENGER TRAIN SPEEDS—Continued

Contd.

Curvature	Speeds M.P.H. Frt. 30 Pass. 50			Speeds M.P.H. Frt. 30 Pass. 55			Speeds M.P.H. Frt. 35 Pass. 60		
	Elev. Frt.	Elev. Pass.	Av. Elev.	Elev. Frt.	Elev. Pass.	Av. Elev.	Elev. Frt.	Elev. Pass.	Av. Elev.
0° 30'	5/16	13/16"	½"	5/16"	1"	¾"	3/8"	1¼"	¾"
1° 00'	9/16	1-5/8	1	9/16	2	1¼	13/16	2½	1¾
1° 30'	7/8	2½	1¾	7/8	3	2	1-3/16	3-11/16	2½
2° 00'	1-3/16	3-5/16	2¼	1-3/16	4	2½	1-5/8	4-15/16	3¼
2° 30'	1½	4-1/8	2¾	1½	5	3¼	2	5-15/16	4
3° 00'	1¾	4-15/16	3¼	1¾	6	4	2-7/16	*6	#4¼
3° 30'	2-1/16	5¾	4	2-1/16	*6	#4½	2-13/16	*6	#5½
4° 00'	2-3/8	*6	#4½	2-3/8	*6	#5			x
4° 30'	2-11/16	*6	#5	2-11/16	*6	#5¾			x
5° 00'	2-15/16	*6	#5½			x			
5° 30'			x			x			
6° 00'			x						
6° 30'									
7° 00'									
7° 30'									
8 00'									

Note: * Theoretical elevation is greater than 6".
Average of theoretical elevations
x Maximum permissible superelevation of 6"

Lehigh Valley—G. A. Phillips, Engineer Maintenance of Way

Attached hereto is copy of our curve elevation table (same as A.R.E.A.). The maximum speed permitted is 70 miles per hour except on curves when the speed is in accordance with the requirements of the table attached.

Louisville & Nashville—J. R. Watt, General Roadmaster

Attached hereto is sheet from our rule book, which shows our elevation table (similar to A.R.E.A.).

We leave it to the Division Engineer largely to fix the elevation, with the table as a guide.

I do not know of any better method, for after all it has to be a matter of experience. I doubt if there is any railroad where the elevation for curves is fixed without careful consideration of the new elevation in comparison with the present.

The riding condition and rail wear are taken to indicate whether the curve needs more or less elevation than it has.

The Louisville & Nashville consists largely of lines built before the days of low grade lines, and in a country where grades could not be avoided. The result is that trains move up the grades slowly and make good speed down-grade. A compromise has be to resorted to. Where the curves are sharp, the speed down the grade is limited so as to enable a better adjustment of the elevation.

Trains very often run at speeds 25 per cent in excess of that for which elevation was fixed. For instance, on 6-degree curve, we usually carry about 6-inch elevation, which corresponds to about 40 m.p.h. Trains very often make 50 m.p.h. around these curves comfortably.

Missouri-Kansas-Texas—Frank Ringer, Chief Engineer

Following extracts from M-K-T Lines Rules and Instructions for the Maintenance of Way and Structures cover our practice as to curve elevation:

"The inner rail of track shall be maintained at grade and the proper curve elevation provided by raising the outer rail.

"The full elevation of outer rail shall be maintained throughout the central curve and shall decrease uniformly along the easement curves to level at tangent points; for curves without easements, the elevation shall be run out on the tangents one-half inch to each full length rail.

"The elevation of curves must be adapted to the speed of all classes of trains which pass over them, with due regard for safety, comfort and economy in track maintenance.

"Curve elevation shall be in accordance with the following table (similar to A.R.E.A. table).

"The amount of elevation shall be fixed for each curve by the district engineer and must not exceed seven (7) inches; foremen must not elevate curves without engineer's stakes, except in emergency.

"Where the relative wear of rails or other conditions indicates too much or too little elevation, the necessary adjustments in elevation or speed of train shall be made promptly.

"It is important that elevation be maintained uniformly throughout the curve."

Our standard time card speed limit for main line is 60 miles per hour. Curve elevation, as stated in quotation from instructions, is fixed for each curve by district engineer according to individual conditions. In general, on main lines where other conditions do not limit speed the track is elevated for 55 to 60 miles per hour.

Missouri Pacific—A. A. Miller, Engineer Maintenance of Way

Copy of our curve elevation table is attached (similar to A.R.E.A. elevations, except slightly higher).

Curves are elevated for fastest trains, and in general speed of not to exceed five miles per hour in excess of rated speed is permitted. If the rated speed on any territory would call for a superelevation in excess of six inches for any given curve in that territory, a local permanent speed restriction is introduced in order to balance actual speed to superelevation.

Nashville, Chattanooga & St. Louis—Hunter McDonald, Chief Engineer

We have found it necessary, in our practice, to absolutely depart from the table of elevations promulgated by the A.R.E.A. (Table on page 184, 1921 Manual.)

We have found it essential, on account of the fact that we are handling tonnage trains as well as high speed freight trains and high speed passenger trains over a single track, to reduce our elevations to a safe compromise.

Enclosed is a table which I propose to substitute for the table of elevations appearing in Rule 372 of Book of Rules and Instructions for Government of Maintenance of Way Employees. This table has not as yet been issued to our foremen (October 24, 1927); however, the practice has been in effect to a more or less extent for a number of years.

In preparation of this table, we have used a formula, the factor of which you will note is considerably lower than that used in the A.R.E.A. Manual of 1921. In this table I have undertaken to utilize the permissive variations set forth in Attachment "B."*

In considering my views on the question, it must be borne in mind that my experience has been limited to this system composed chiefly of single track, upon every part of which we find it necessary to make variations from any theoretical standard which may be set up.

*Attachment "B" is copy of Pennsylvania Table shown herein, which was taken from table on page 184 of the 1921 Manual and graphs appearing on pages 189, 190 and 191 of that Manual.

New York Central—East and West—J. V. Neubert, Chief Engineer Maintenance of Way

CURVE ELEVATIONS FOR NORMAL CONDITIONS
Formula Used: $E=.000435DS^2$ (See Page 184 of A.R.E.A.Manual for 1921)

Useful Data For Variations

Deg. of Curve	Speed in Miles Per Hour 20	25	30	35	40	45	50	55	60	"A" Safe Elevation	"B" Overturning Elev.&Speeds
1		½	½	1	1	1	1	1½	1½	None at 70 M	None 100 M
22	½	½	1	1	1½	2	2	2½	3	None at 63 M	None 100 M
3	½	1	1	1½	2	2½	3	4	4½	2" at 60 M,	None- 95 M, 2" -100 M
4	½	1	1½	2	3	3½	4½	5	5½	4" at 60 M.	None- 83 M, 5½" - 96 M
5	1	1½	2	2½	3½	4½	5½			3" at 50M	None- 74 M 5½" - 86 M
6	1	1½	2½	3	4	5				2½" at 45 M.	None- 67 M 5" - 78 M
8	1½	2	3	4	5½					3" at 40 M.	None- 58 M 5½" - 68 M
10	2	2½	4	5½						2½" at 35 M	None- 52 M 5½" - 61 M
12	2	3½	4½							1½" at 30 M	None- 48 M 4½" - 55 M
14	2½	4	5½							3" at 30 M	None- 44 M 5½" - 52 M
16	3	4½								1" at 25 M	None- 42 M 4½" - 47 M
18	3	5								2" at 25 M	None- 39 M 5" - 45 M

The above table is to be substituted for that appearing in Rule 372 of "Rules and Instructions for Maintenance of Way Employees, dated Aug. 1, 1923.

Column "A", are values read from Graph shown on page 190 of AREA Manual for 1921

Column "B" are values read from Graph shown on page 191 of AREA Manual for 1921

We use formula $E = \dfrac{V^2 \times G}{32-2 \times R}$

Where $E =$ elevation in inches
$V =$ velocity in feet seconds
$G =$ gage in inches
$R =$ radius of curve in feet
$32-2 =$ acceleration per second due to gravity

and applying in the field full equilibrium elevation unless covered by special speed restrictions. Where both slow and fast freight trains operate, we use one-inch elevation to the degree unless covered by special speed restriction. On track where trains operate at all speeds, we use full equilibrium elevation with speed restriction where local conditions warrant.

A copy of our curve elevation table is attached (similar to A.R.E.A. except very slightly higher elevations are used).

Ohio Central

Territory—Normal Speed 60 M.P.H.—Superelevate 2 inches per degree of curve with maximum of 6 inches. Curves more than 4 degrees protected by permanent slow order.

Territory—Normal Speed 50 M.P.H.—Superelevate 1½ inches per degree of curve with maximum of 6 inches. Curves more than 5 degrees 30 minutes protected by permanent slow order.

Territory—Normal Speed 40 M.P.H.—Superelevate 1 inch per degree of curve with maximum of 6 inches. Curves more than 8 degrees 30 minutes protected by permanent slow order.

Territory—Normal Speed 30 M.P.H.—Superelevate ½ inch per degree of curve with maximum of 6 inches. Curves more than 12 degrees protected by permanent slow order.

On most of the Ohio Central, it is necessary to superelevate the curves for a speed somewhat less than allowable passenger train speed in order to avoid excessive superelevation for freight train operation. We have never gone so far as 3-inch unbalanced superelevation but have held our figures to about one-half that amount so that in case the timetable speed is exceeded, we will still be within the 3-inch unbalanced superelevation.

Boston & Albany

Use full equilibrium elevation in accordance with table attached (see Attachment 2).

All curves are elevated for an excess of 5 M.P.H. over allowable speed.

Big Four

"Use A.R.E.A. Curve Elevation Table shown in A.R.E.A. Manual of 1921, page 184.

"Where curves are not elevated for the fastest speed, the speed over such curves is limitd by timetable instructions to a speed that is safely within limit of speed for which curves are elevated.

Michigan Central

Use A.R.E.A. Curve Elevation Table shown in A.R.E.A. Manual of 1921, page 184.

Our main line curves are elevated for a speed of 55 m.p.h. and over such curves the timetable permits a maximum speed of 70 m.p.h.

Pittsburgh & Lake Erie

Use approximately the amount of superelevation as outlined in A.R.E.A. table given in Manual for 1921, page 184.

Use judgment as to variations from this table to meet local conditions.

Rutland

Use A.R.E.A. Curve Elevation Table shown in A.R.E.A. Manual of 1921, page 184.

Curves on grades are not elevated for the fastest speed of trains down grade, but trains descending that grade are restricted to speed well within safety as shown by column of comfortable speed on proposed table.

Indiana Harbor Belt

Use A.R.E.A. Curve Elevation Table shown in A.R.E.A. Manual of 1921, page 184.

Passenger trains not operated. Both fast and slow freight trains operated. The speed limit is 40 miles per hour. Fastest trains, therefore, required to slow down when proceeding around sharp curves.

Chicago Junction—Chicago River & Indiana

No standard curve elevation table.

Train movements are all slow moving freight and not necessary to have a standard curve elevation table.

Nickel Plate Road—F. S. Hales, Engineer of Track

We use the A.R.E.A. table. Our curves are generally elevated for 50 miles per hour and a speed of some 12 to 15 miles per hour in excess of that shown on the table is generally permitted.

Norfolk & Western—W. P. Wiltsee, Chief Engineer

You will note from our Curve Elevation Table that on our main line the speeds for different degrees of curvature are a mean between the equilibrium speed and the comfortable speed. We have purposely fixed our elevations in this manner because of the character of traffic.

On this railroad, we have heavy coal tonnage, which must necessarily run slower than our passenger trains, and consequently the elevation of outer rail has been fixed in order to take care of these as well as the passenger movement.

We do not use any curve-elevation boards, like those used by a good many other railroads, but the track forces are governed by the tables on the attached prints of L-318. We do not permit speeds in excess of those shown in these tables.

~ POCAHONTAS DIVISION ~

TABLE OF ELEVATIONS OF OUTER RAIL ON CURVES GIVING MAXIMUM SPEEDS

Degree of Curve	Bluefield to Bluestone		Bluestone to Vivian: With grades		Bluestone to Vivian: Against Grades of 1% and over		Vivian to Williamson		Graham to Norton		Dry Fork Branch		Bluestone Br, Pocahontas, North Fork, Tug Fork		Crane Creek Br, Spice Creek, Clear Fork, Pond Creek, Toms Creek		Jacobs Fork Branch		All other Branches	
	Super Elevation	Max Speed M P H	Super Elevation	Max Speed M P H	Super Elevation	Max Speed M P H	Super Elevation	Max Speed M P H	Super Elevation	Max Speed M P H	Super Elevation	Max Speed M P H	Super Elevation	Max Speed M P H	Super Elevation	Max Speed M P H	Super Elevation	Max Speed M P H	Super Elevation	Max Speed M P H
1°	1	40	1"	40	½"	38	1	40	1	40	½	25	½"	20	½"	20	½	25	½"	12
2°	2"	40	2"	40	1	34	2	40	2	40	1	25	1"	20	1"	20	1"	25	1"	12
3°	3"	40	3"	40	1½	32	3	40	3"	40	1½	25	1½	20	1½"	20	1½	25	1½	12
4°	4"	40	4	40	2	31	4"	40	4	40	2	25	2"	20	2	20	2"	25	2"	12
5°	5	40	5	40	2½"	30	5	40	5	40	2½"	25	2½"	20	2½"	20	2½	25	2½	12
6°	5	39	5"	39	3"	30	5		5	39	3"	25	3	20	3"	20	3"	25	3	12
7°	5	36	5"	36	3½"	29	5		5	36	3½"	25	3½"	20	3"	20	3	25	3	12
8°	5"	34	5"	34	4"	29	5		5	34	3½"	25	3½"	20	3"	20	3"	25	3"	12
9°	5	32	5	32	4½"	28	5		5	32	3½	24	3½	20	3"	20	3	25	3"	12
10°	5	30	5	30	4½"	27	5"		5	30	3½"	23	3½	20	3"	20	3"	24	3"	12
11°	5"	29	5"	29	4½	26	5		5"	29	3½"	22	3½	20	3"	20	3"	22	3"	12
12°	5"	27	5	27	4½	25	5"		5	27	3½"	21	3½"	20	3"	20	3"	20	3"	12

(Vivian to Williamson, Max Speed, 6° to 12°: May be increased [illegible] where high speed [illegible] used on curves [illegible])

~ SHENANDOAH DIVISION ~

TABLE OF ELEVATIONS OF OUTER RAIL ON CURVES GIVING MAXIMUM SPEEDS

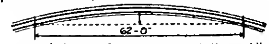
Degree of Curve	Roanoke to Winston Salem		Hagerstown to Roanoke	
	Super Elevation	Max Speed M P H	Super Elevation	Max Speed M P H
1°	1	45	1"	55
2°	2"	45	2"	48
3°	3"	45	3"	45
4°	4"	43	4	43
5°	5"	42	5	42
6°	5"	39	6	39
7°	5"	36	6"	36
8°	5"	34	6"	34
9°	5"	32	6	32
10°	5"	30	6"	30

(Hagerstown to Roanoke, vertical note: May be increased [illegible] where high speed [illegible])

NOTE:—
Maximum speed in miles per hour as shown on this plan was taken from the current Division Time Tables.

NOTE:

To find degree of any curve, mark two points on the side of the rail head 62 feet apart and stretch a line between these points touching the rail thus:



The distance from the line at the middle point to the side of the rail head will be one inch for each degree of curve, that is, it will be one inch on a one degree curve, two inches on a two degree curve and so on. Elevations of outer rail on passing sidings and low speed side tracks shall not exceed two inches. No elevation should be given outer rail on yard tracks and commercial sidings when speed does not exceed 15 miles per hour. Curves of ten degrees or over to be protected by curve boards. See plan L-182.

The grade line should be maintained along the inner rail and the elevation obtained by raising the outer rail.

Where a permanent structure establishes the elevation of the outer rail, the same shall be maintained on curved rail adjoining, according to plan.

Curves to have 75% of full elevation at point of curve, and elevation to run out on tangents at the rate of 1" in 66', except where tangents are too short to provide for standard run-off in the elevation.

In case a tangent is located between two reverse curves and tangent should be too short to use a standard run-off in the super-elevation, track should be made level at the center of such tangent and in no case shall the run-off exceed 1" to 33' as it will be better to reduce the super-elevation at point of curve below 75% of the full elevation rather than have the run-off exceed 1" in 33'.

(Vertical, beside the last two paragraphs: For Curves which are not spiraled)

NORFOLK & WESTERN RAILWAY
STANDARD
SUPER-ELEVATION OF OUTER RAIL ON CURVES

Recommended for Approval: W. P. Wiltsee
Chief Engineer

Approved: N. D. Jenks
Vice-President

~Revised Jan. 6-1926~

OFFICE OF CHIEF ENGINEER.... ROANOKE VA.... SEPT. 25TH 1925

Northern Pacific—L. Yager, Assistant Chief Engineer

Attached hereto is a copy of table for elevation of outer rail on curves appearing in our Standard Instructions (similar to A.R.E.A., except slightly higher).

These are a guide and are intended to represent so-called "balanced elevations." The Roadmasters adjust the elevation in each case in order to obtain a fairly well balanced rail wear on curves, and at the same time preserve satisfactory riding qualities. The Northern Pacific is still largely a single track railroad so that a compromise is really necessary to fit the wider divergence of requirements of passenger train and freight train speed. This necessity for compromise is particularly evident on heavy grades.

We have a practice of providing markers giving speed limits at each curve where the question of speed is at all important. These designations are fixed by the local officers and are not a matter of record with the Engineering Department.

Pere Marquette—H. A. Cassil, Chief Engineer

If all trains ran at the same speed, it would be an easy matter to elevate the curves for the speed of the train. This, however, does not work out in practice where trains are run at high and low rates of speed over the same curves. Therefore, it is necessary to make a compromise to suit the conditions.

In general the speed of our passenger trains is restricted to 60 miles per hour and that of freight trains to 30 miles per hour, and we make a compromise, elevating the curves for a speed of 50 miles per hour, using the table and formula as given in the A.R.E.A. Manual. There are places where we do not elevate for this speed, due to local conditions restricting the speed of the trains.

Pennsylvania Railroad—T. J. Skillman, Chief Engineer

We herewith enclose a copy of our latest specifications on this subject, dated April 22, 1925. The data given are all taken from the A.R.E.A. Manual, but it seems to us that we have more clearly expressed the ideas in the Manual than the Manual itself expresses them, and we, therefore, believe the Manual should be altered and clarified, not because it fails to contain all the necessary information to cover any particular case, but because it seems to be misunderstood by a good many people.

"The instructions in C.E. 78 (c), as to the superelevation of the outer rail on curves, do not appear to be uniformly applied or interpreted, and we have, therefore, concluded to elaborate them.

"The table hereto appended shows four sets of speeds in miles per hour for each degree of curve:

"(1) The equilibrium speeds for each inch of superelevation, obtained by applying the centrifugal force formula $E = .0007\ V^2D$.

"(2) The comfortable speeds with three inches unbalanced elevation, obtained as set forth in Proceedings American Railway Engineering Association for 1914, pages 570 to 577, inclusive. There may be some question as to whether these figures do really represent the maximum comfortable speeds, but, in our judgment, they are conservative.

"(3) The maximum theoretically safe speeds, that is to say, the speeds at which the resultants—assuming the center of gravity at 84 inches above the rails, a figure in excess of the height of any of our rolling stock—pass through the edge of the middle third of the track. While the middle third may be thought to be too conservative, the irregularities in line and surface found in the tracks and actual experience of derailments do not support that idea.

"(4) The overturning speeds, at which the resultants pass through the gage line of the outer rail."

The table may be used in either of two ways—one to determine the superelevation of the outer rail necessary to permit a given comfortable speed, the other to determine the speed restrictions which should be imposed after the best superelevation has been determined consistently with the passenger train movement, the tonnage freight train movement and the wear of rails, ties and rail fastenings.

Speeds exceeding ninety per cent of the comfortable speeds should not be officially authorized.

Should a three-degree curve exist in a part of the line containing lighter curves and no heavy adverse grades for a distance of several miles, it may be advisable to elevate the outer rail on that curve as much as six inches so as not to restrict the speed of fast passenger trains unnecessarily, though such an elevation would have a bad effect on the wear of the track material and would retard the movement of tonnage freight trains. If, however, the three-degree curve was part of a line containing numerous sharper curves, or on which the grades or other conditions restricted the speed of passenger trains, it would not be wise to elevate the three-degree curve more than enough to give comfortable riding at the speed restricted by the rest of the line.

It will be observed that on the sharper curves increased elevation allows very little higher comfortable speed, and in such cases the wear of the track materials and the resistance of tonnage freight trains may well be the controlling factors as to elevation and speed restrictions.

Table of Train Speeds, in Miles Per Hour, on Curves of Given Degrees and With Given Superelevations in Inches of Outer Rail

Degrees of Curves	Kinds of Speeds	Super-Elevations in Inches							
		0	1	2	3	4	5	6	7
		Speeds in Miles Per Hour							
1° 00'	: Equi.	--	39	56	67	78	87	95	102
	: Comf.	68	78	87	96	103	111	118	124
	: Safe.	90	98	106	113	120	126	132	138
	: Over.	166	171	176	181	185	190	195	199
2° 00'	: Equi.	--	28	39	48	55	62	67	73
	: Comf.	48	55	62	68	73	78	83	88
	: Safe.	64	70	75	80	85	89	93	98
	: Over.	117	121	124	128	131	134	138	141
3° 00'	: Equi.	--	23	32	39	45	50	55	59
	: Comf.	39	45	50	55	60	84	68	72
	: Safe.	52	57	61	65	69	73	76	80
	: Over.	96	99	102	104	107	110	112	116
4° 00'	: Equi.	--	19	28	34	39	43	48	50
	: Comf.	34	39	44	48	52	55	59	62
	: Safe.	45	49	53	57	60	63	66	69
	: Over.	83	85	88	90	93	95	97	100
5° 00'	: Equi.	--	17	25	30	35	39	43	46
	: Comf.	30	35	39	43	46	50	53	56
	: Safe.	40	44	47	51	54	56	59	62
	: Over.	74	78	79	81	83	85	87	89
6° 00'	: Equi.	--	16	22	27	32	36	39	42
	: Comf.	28	32	36	39	42	45	48	51
	: Safe.	37	40	43	46	49	51	54	56
	: Over.	68	70	72	74	76	78	80	81
7° 00'	: Equi.	--	13	21	25	30	33	36	39
	: Comf.	26	30	33	36	39	42	44	47
	: Safe.	34	37	40	43	45	48	50	62
	: Over.	63	65	66	68	70	72	74	75
8° 00'	: Equi.	--	14	20	24	28	31	34	36
	: Comf.	24	28	31	34	37	39	42	44
	: Safe.	32	33	37	40	42	45	47	49
	: Over.	59	60	62	64	66	67	69	71
9° 00'	: Equi.	--	13	18	22	26	29	32	34
	: Comf.	23	26	29	32	35	37	39	41
	: Safe.	30	33	35	38	40	42	44	46
	: Over.	65	57	59	60	62	63	65	66
10° 00'	: Equi.	--	12	17	21	25	28	30	33
	: Comf.	21	25	28	30	33	35	37	39
	: Safe.	29	31	34	36	38	40	42	44
	: Over.	53	54	66	57	59	60	62	63

Degrees of Curves	Kinds of Speeds	Super-Elevations in Inches: 0	1	2	3	4	5	6	7
		Speeds in Miles per Hour							
12° 00'	:Equi.	--	11	16	19	22	25	27	30
	:Comf.	20	23	25	28	30	32	32	36
	:Safe	26	28	31	33	35	36	38	40
	:Over.	46	49	51	52	54	55	56	58
14° 00'	:Equi.	--	10	15	18	21	23	25	28
	:Comf.	18	21	23	26	28	30	31	33
	:Safe	24	26	28	30	32	34	35	37
	:Over.	44	46	47	48	50	51	52	53
16° 00'	: Equip.	--	10	14	17	19	22	24	26
	:Comf.	17	20	22	24	26	28	29	31
	:Safe	23	25	27	28	30	32	33	35
	:Over.	42	43	44	45	46	48	49	50
18° 00'	:Equi.	--	9	13	16	18	20	22	24
	:Comf.	16	18	21	23	24	26	28	29
	:Safe	21	23	25	27	28	30	31	33
	:Over.	39	40	41	43	44	45	46	47
20° 00'	:Equi.	--	9	12	15	17	19	21	23
	:Comf.	15	17	20	21	23	25	26	28
	:Safe	20	22	24	25	27	28	30	31
	:Over.	37	38	39	40	41	43	44	45

Speeds after "Equi." are Equilbrium Speeds
" " "Comf." " Comfortable Speeds
" " "Safe" " Maximum Safe Speeds
" " "Over." " Overturning Speeds.

St. Louis Southwestern—W. S. Hanley, Chief Engineer

We have been using the curve elevation table as shown in the 1921 Manual, as per Attachment A.

Our curves are elevated for our fastest trains, permitting no excess in speed provided for by the elevation.

Seaboard Air Line—J. L. Kirby, Engineer Maintenance of Way

We elevate our curves for the fastest speed that will be run according to rules (elevations slightly less than A.R.E.A.).

Texas & Pacific—R. H. Gaines, Engineer Maintenance of Way

I attach a copy of our superelevation tables. This is taken from the A.R.E.A. Manual of 1921. We think it represents about the best thing that has been offered in the way of superelevation tables, at least a satisfactory system of superelevation if applied rationally.

It is our general practice to elevate the curves to meet the requirements of our passenger trains. On that part of our main line traversed by our fastest passenger trains we hold pretty close to a superelevation to accommodate a speed of 50 miles per hour—this is varied a little by local conditions which are worked out in detail with our Roadway Officials on the ground. We have a few curves at the summit of grades where our passenger trains do not normally make a speed of 50 miles per hour and at these places the superelevation is correspondingly reduced.

It is our practice to not put in a superelevation in excess of 5½ inches—with this superelevation as a limiting factor and the degree of curvature as another factor, we reduce the speed of trains to conform. However, will say that we have on our property only two or three curves where these conditions prevail. On our branch lines the superelevation is made to conform to the location conditions as respect speed, etc.

Union Pacific—S. H. Osborne, Engineer Maintenance of Way

Curves on Union Pacific unit are elevated with view to giving best riding condition on passenger trains, and elevation is governed principally by the average speed of trains at curve elevation. Generally speaking, at points where speed limit is readily obtained by passenger trains, elevation for that limit is used. At points where speed of such trains, by reason of grade, averaging less than the limit, curves are elevated on basis of such average, that is, on double track in 50-mile territory, on heavy ascending grades, elevation of curve may be on basis of speed of 35 or 40 m.p.h. On single track speeds more nearly approximate the train speed restriction, for the reason that a train moving in one direction may be necessarily operated considerably below allowable speed limit, while train in opposite direction may easily obtain such speed. We figure on single track with speed limit of 60 m.p.h., an easy riding curve may be obtained if elevated for speed of 50 m.p.h., both at the 60-mile and the 40-mile speed; in other words, a variation of 10 miles either side of elevation speed will give reasonably good riding conditions. Also, such elevation is safe for speed varying 20 miles in either direction.

Oregon-Washington Railroad & Navigation Company—H. A. Roberts, Engineer Maintenance of Way

Our maximum speed is 60 miles per hour; over 5-degree and 6-degree curves the maximum allowable speed is 40 miles per hour; 7-degree and 8-degree curves, 35 miles per hour, and on 9-degree and 10-degree curves, 30 miles per hour. Our maximum elevation of outer rail on curves is 5½ inches.

Wabash—R. H. Howard, Chief Engineer

We use A.R.E.A. table and elevate for a speed of 60 miles per hour, and a maximum elevation of six inches. Exceptions are made to the general rule on some curves where the location and grade are controlling factors.

Conclusions

That the Committee's report submitted in this Appendix (Appendix B) be received as information, and that with the recommendations for changes in the Manual coming under this subject, as presented in Appendix A, this assignment now be considered as completed.

Appendix C

(3) DETAILED PLANS OF SWITCHES, FROGS, CROSSINGS, AND SLIP SWITCHES

C. R. Harding, Chairman, Sub-Committee; J. V. Neubert, J. B. Akers, W. G. Brown, L. H. Bond, E. W. Caruthers, J. W. DeMoyer, L. W. Deslauriers, E. B. Entwisle, O. F. Harting, W. G. Hulbert, F. R. Masters, J. de N. Macomb, J. C. Mock, A. J. Neafie, G. A. Peabody, W. H. Petersen, O. C. Rehfuss, I. H. Schram, G. J. Slibeck, G. M. Strachan, J. B. Strong.

The plans presented in this Appendix and revisions to the Manual in Appendix A, coming under this subject have been prepared in conference with the Standardization Committee of the Manganese Track Society.

Item I—Frog Lengths for Heavy Rail for Uniform Tie Spacing

The Committee offers for adoption as recommended practice the following seven plans covering frogs for heavy rail and showing uniform tie layouts suitable for any type of guard rail.

Plans, dated November, 1928, of rail bound manganese steel, bolted rigid, spring rail and solid manganese steel frogs:

No. 273, A.R.E.A. No. 6 frogs for heavy rails.
No. 274, A.R.E.A. No. 7 frogs for heavy rails.
No. 275, A.R.E.A. No. 8 frogs for heavy rails.
No. 276, A.R.E.A. No. 9 frogs for heavy rails.
No. 277, A.R.E.A. No. 10 frogs for heavy rails.
No. 278, A.R.E.A. No. 11 frogs for heavy rails.
No. 279, A.R.E.A. No. 12 frogs for heavy rails.

To complete this set of plans the Committee also has under consideration plans of No. 14, No. 15 and No. 16 rail bound manganese steel and bolted rigid frogs for heavy rails, and plans of No. 18 and No. 20 railbound manganese steel frogs for heavy rails, which it expects to present in a report at a later date.

The Committee offers to be received as information Plans No. 271 and No. 272 for heavy rails as companion plans to plans covering No. 4 and No. 5 frogs for lighter rails, namely, No. 309 of No. 4 and No. 5 bolted rigid frogs; No. 608 of No. 4 and No. 5 rail bound manganese steel frogs; and No. 656 of No. 4 and No. 5 solid manganese steel frogs, accepted as information in March of 1921, as follows:

Plans, dated November, 1928, of rail bound manganese steel, bolted rigid and solid manganese steel frogs:

No. 271, A.R.E.A. No. 4 frogs for heavy rails.
No. 272, A.R.E.A. No. 5 frogs for heavy rails.

Item II—Flange or Self-Guarded Frogs

Last year Plan No. 343, dated November, 1927, of A.R.E.A. No. 8 self-guarded bolted rigid frog, was presented as information to invite criticism.

The Committee now offers this plan (No. 343), dated Revised November, 1928, with some slight modifications, for adoption as recommended practice.

The following additional plans of self-guarded bolted rigid frogs, prepared in line with Plan No. 343, are also offered for adoption as recommended practice:

Plan No. 341, dated Nov., 1928, A.R.E.A. No. 6 self-guarded bolted rigid frog.

Plan No. 342, dated Nov., 1928, A.R.E.A. No. 7 self-guarded bolted rigid frog.

Plan No. 344, dated Nov., 1928, A.R.E.A. No. 10 self-guarded bolted rigid frog.

Item III—One-Piece Guard Rails

Plan No. 510 of A.R.E.A. manganese steel one-piece guard rail, 8 ft. 4½ in. length for installation on six ties, dated November, 1928, is presented as information to invite criticism.

It is the intention of the Committee to prepare a series of plans or specifications to cover other lengths of one-piece guard rails, specifying application of turnout plans, which will be presented at a later date.

Item IV—Adjustable Rail Braces

The Committee offers for adoption as recommended practice written Plan No. 240, dated November, 1928, of A.R.E.A. specifications for adjustable rail braces.

Conclusions

The Committee recommends that the following plans submitted herewith be adopted as recommended practice and printed in the Manual:

Plan No. 273, dated Nov., 1928, A.R.E.A. No. 6 frogs for heavy rails—rail bound manganese steel, bolted rigid, spring rail and solid manganese steel.

Plan No. 274, dated Nov., 1928, A.R.E.A. No. 7 frogs for heavy rails—rail bound manganese steel, bolted rigid, spring rail and solid manganese steel.

Plan No. 275, dated Nov., 1928, A.R.E.A. No. 8 frogs for heavy rails—rail bound manganese steel, bolted rigid, spring rail and solid manganese steel.

Plan No. 276, dated Nov., 1928, A.R.E.A. No. 9 frogs for heavy rails—rail bound manganese steel, bolted rigid, spring rail and solid manganese steel.

Plan No. 277, dated Nov., 1928, A.R.E.A. No. 10 frogs for heavy rails—rail bound manganese steel, bolted rigid, spring rail and solid manganese steel.

Plan No. 278, dated Nov., 1928, A.R.E.A. No. 11 frogs for heavy rails—rail bound manganese steel, bolted rigid, spring rail and solid manganese steel.

Plan No. 279, dated Nov., 1928, A.R.E.A. No. 12 frogs for heavy rails—rail bound manganese steel, bolted rigid, spring rail and solid manganese steel.

Plan No. 341, dated Nov., 1928, A.R.E.A. No. 6 self-guarded bolted rigid frog.

Plan No. 342, dated Nov., 1928, A.R.E.A. No. 7 self-guarded bolted rigid frog.

Plan No. 343, dated Revised Nov., 1928, A.R.E.A. No. 8 self-guarded bolted rigid frog.

Plan No. 344, dated Nov., 1928, A.R.E.A. No. 10 self-guarded bolted rigid frog.

Plan No. 240, dated Nov., 1928, A.R.E.A. specifications for adjustable rail braces.

The Committee also recommends that the following plans submitted herewith be received as information:

Plan No. 271, dated Nov., 1928, A.R.E.A. No. 4 frogs for heavy rails—rail bound manganese steel, bolted rigid, and solid manganese steel.

Plan No. 272, dated Nov., 1928, A.R.E.A. No. 5 frogs for heavy rails—rail bound manganese steel, bolted rigid, and solid manganese steel.

Plan No. 510, dated Nov., 1928, A.R.E.A. manganese steel one-piece guard rails, 8 ft. 4½ in. length for installation on six ties.

The Committee recommends that this subject be continued.

Appendix D

(4) TRACK CONSTRUCTION IN PAVED STREETS

E. W. Caruthers, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, W. G. Brown, J. W. DeMoyer, J. E. Deckert, E. B. Entwisle, W. J. Harris, W. G. Hulbert, J. de N. Macomb, J. C. Mock, A. J. Neafie, G. A. Peabody, O. C. Rehfuss, G. J. Slibeck, G. M. Strachan, J. B. Strong, T. P. Warren, J. R. Watt.

The Committee reports progress on this subject for this year, and recommends that the assignment be continued.

Appendix E

(5) DESIGN AND SPECIFICATIONS FOR FOUNDATIONS UNDER RAILWAY CROSSINGS; ALSO PROPER METHODS FOR TIE SPACING AND TIMBERING UNDER RAILWAY CROSSINGS

O. F. Harting, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, C. W. Breed, H. W. Brown, W. G. Brown, L. H. Bond, E. W. Caruthers, H. R. Clarke, E. B. Entwisle, J. M. Fair, F. S. Hales, W. J. Harris, W. G. Hulbert, H. D. Knecht, F. R. Masters, J. B. Myers, A. J. Neafie, W. H. Petersen, O. C. Rehfuss, I. H. Schram, G. J. Slibeck, E. D. Swift.

The plans presented in this Appendix have been prepared in conference with the Standardization Committee of the Manganese Track Society.

Last year the Committee presented Plan No. 721, dated November, 1927, A.R.A.E. design of reinforced concrete and pile crossing foundations, which plan was adopted as recommended practice in March of this year, thus completing the first part of this assignment.

The Committee has presented as information to invite criticism:

Plans Nos. 719-A, 719-B and 719-C, dated November, 1927, tie layouts for railroad crossings covering angles ranging from 8 deg. and 10 min. to 50 deg., accepted as information March, 1928;

And Plan No. 720, dated December, 1925, tie layouts for railroad crossings for angles 50 to 90 deg., accepted as information March, 1926.

The following revised plans are now presented, which the Committee recommends for adoption as recommended practice:

Plan No. 719-A, dated Revised November, 1928, A.R.E.A. tie layouts for railroad crossings, angles 8 deg. 10 min. to 14 deg. 15 min.

Plan No. 719-B, dated Revised November, 1928, A.R.E.A. tie layouts for railroad crossings, angles 14 deg. 15 min. to 25 deg.

Plan No. 719-C, dated Revised November, 1928, A.R.E.A. tie layouts for railroad crossings, angles 25 deg. to 50 deg.

Plan No. 719-D, dated November, 1928, A.R.E.A. tie layouts for railroad crossings, angles 50 to 90 deg.

Plan No. 719-D takes the place of information Plan No. 720 above mentioned as a revision of the same.

Conclusions

The Committee recommends that the following series of four plans, submitted herewith, be adopted as recommended practice and printed in the Manual:

Plan No. 719-A, dated Revised November, 1928, A.R.E.A. tie layouts for railroad crossings, angles 8 deg. 10 min. to 14 deg. 15 min.

Plan No. 719-B, dated Revised November, 1928, A.R.E.A. tie layouts for railroad crossings, angles 14 deg. 15 min. to 25 deg.

Plan No. 719-C, dated Revised November, 1928, A.R.E.A. tie layouts for railroad crossings, angles 25 deg. to 50 deg.

Plan No. 719-D, dated November, 1928, A.R.E.A. tie layouts for railroad crossings, angles 50 to 90 deg.

With the above report this assignment is now considered as completed.

Appendix F

(6) METHODS OF REDUCING RAIL WEAR ON CURVES WITH PARTICULAR REFERENCE TO OILING THE RAIL OR WHEEL FLANGES

C. M. McVay, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, W. G. Arn, W. H. Bevan, L. W. Deslauriers, J. M. Fair, F. W. Hillman, E. T. Howson, H. D. Knecht, G. M. Strachan, J. B. Strong, E. D. Swift.

Your Committee finds that about 30 railways have tried various methods of oiling the rail and wheel flanges. Some of the roads have experimented in a small way only, while others have extended the practice to cover long sections of the road. There seems to be general agreement on the following points:

(1) Oiling, with proper and suitable oil, will considerably reduce side or flange wear on the high rail of curves.

(2) Under ordinary conditions oil can be successfully applied by hand or by machines.

(3) The amount of oil required varies with the amount of traffic carried by the track and physical characteristics of the track, such as curvature, grades, etc.

(4) Other advantages, not readily convertible into tangible items are gained; such as (a) decreased gaging of track on curves with attendant savings in maintenance, labor, ties, etc., (b) decreased wear on engine and car wheel flanges, (c) decreased wear on low rail due to reduced abrasion and partial lubrication of wheel sliding action.

As the changing of rail interval on sharp curves is governed principally by traffic carried, local conditions will largely control any problem of this sort. The conditions in various parts of the country and standards of the carriers differ to such an extent that it is impossible to advance any general rule as to where oiling should be attempted or the interval between points of application.

On the Norfolk and Western Railway oiling has been carried on systematically for more than three years. The Committee has attached to this report Exhibits A and B, showing the result of oiling on the N. & W. These exhibits will give an excellent idea of the difference in wear on the high rail before and after oiling, the amount of traffic carried and the relation of same to the wear. Exhibit C is also attached, showing the cost of oiling by different methods at six locations of each method. As the traffic carried at each of the points is the same and other conditions practically similar, the figures are comparable. Oil is applied by four methods covered by this exhibit as follows:

(A) Hand Oiling, by tunnel, cut or other full time watchmen, no labor charged to oiling.

(B) Hand Oiling, where ¼ of laborer's time is charged to oiling. (Labor rate 38 cents per hour.)

A. R. E. A. INDEX

March, 1929

Switches

Split Switches, Layouts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
101	Sep. 15, 1919	16′ 6″ Split Switch with Uniform Risers	Adopted Mar., 1920
102	Sep. 15, 1919	16′ 6″ Split Switch with Graduated Risers	Adopted Mar., 1920
103	Sep. 15, 1919	11′ 0″ Split Switch with Uniform Risers	Adopted Mar., 1920
104	Sep. 15, 1919	11′ 0″ Split Switch with Graduated Risers	Adopted Mar., 1920
105	Sep. 15, 1919	22′ 0″ Split Switch with Uniform Risers	Adopted Mar., 1920
106	Sep. 15, 1919	22′ 0″ Split Switch with Graduated Risers	Adopted Mar., 1920
107	Sep. 15, 1919	30′ 0″ Split Switch with Uniform Risers	Adopted Mar., 1920
108	Sep. 15, 1919	30′ 0″ Split Switch with Graduated Risers	Adopted Mar., 1920

Diagrams of Preferred Names of Parts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
190	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Split Switches with Uniform Risers	Adopted Mar., 1921
191	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Split Switches with Graduated Risers	Adopted Mar., 1921

Split Switch Fixtures

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
201	Sep. 15, 1919	Details of Split Switch Fixtures (General)	Adopted Mar., 1920
202	Sep. 15, 1919	Details of Split Switch Fixtures (Special Features)	Adopted Mar., 1920
203	Sep. 15, 1919	Details of Split Switch Fixtures (Heel Plates and Turnout Plates)	Adopted Mar., 1920
204	Sep. 15, 1919	Details of Split Switch Fixtures (Heel Plates and Turnout Plates for 22′ 0″ and 30′ 0″ Switches)	Adopted Mar., 1920
205	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (General)	Adopted Mar., 1924
206	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (Special Features)	Adopted Mar., 1924
207	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (Heel Plates and Turnout Plates for 11′ 0″ and 16′ 6″ Switches)	Adopted Mar., 1924
208	Nov., 1923	Details of Split Switch Fixtures for Rails 6½″ High and Over (Heel Plates and Turnout Plates for 22′ 0″ and 30′ 0″ Switches)	Adopted Mar., 1924

Illustration Bills of Material

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
210	Sep. 15, 1919	Illustration Bills of Material for 11′ 0″ and 16′ 6″ Split Switches	Adopted Mar., 1920
211	Sep. 15, 1919	Illustration Bills of Material for 22′ 0″ and 30′ 0″ Split Switches	Adopted Mar., 1920
212	Nov., 1923	Illustration Bills of Material for Rails 6½″ High and Over for 11′ 0″ and 16′ 6″ Split Switches	Adopted Mar., 1924

Derail Switch Point

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
213	Nov., 1925	Details for Split Switch Point Derail	Adopted Mar. 1926

Rail Braces

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
240	Nov., 1928	Specifications for Adjustable Rail Braces	**Adopted Mar., 1929

Switch Stands

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
251	Nov. 17, 1920	Switch Stand Connecting Rods *and* Requisites for Switch Stands, including Connecting Rods	Adopted Mar., 1921
252	Nov., 1921	Detail of Lamp Tips for Switch Stands	Adopted Mar., 1922
253	Nov., 1922	Detail of Switch Stand Target Shapes	Adopted Mar., 1923
254	Nov., 1921	Day Target Discs for Switch Lamps	Adopted Mar., 1922
255	Nov., 1922	Switch Lock	Adopted Mar., 1923

Frogs—Heavy Rail

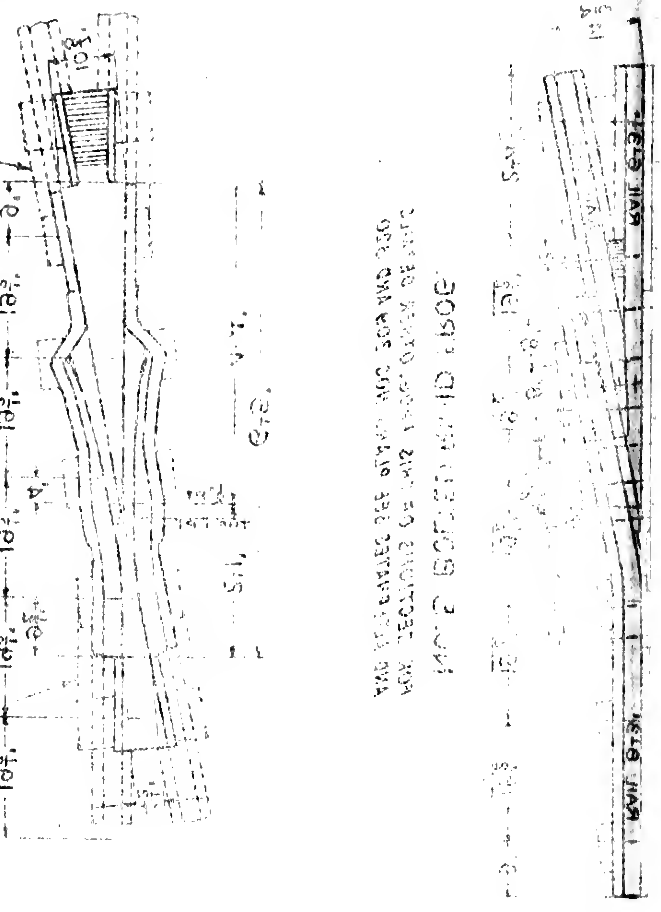
PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
271	Nov., 1928	No. 4 Frogs for Heavy Rails, Rail-Bound Manganese Steel, Bolted Rigid, and Solid Manganese Steel	*Inform. Mar., 1929
272	Nov., 1928	No. 5 Frogs for Heavy Rails, Rail-Bound Manganese Steel, Bolted Rigid, and Solid Manganese Steel	*Inform. Mar., 1929
273	Nov., 1928	No. 6 Frogs for Heavy Rails, Rail-Bound Manganese Steel, Bolted Rigid, Spring Rail, and Solid Manganese Steel	**Adopted Mar., 1929
274	Nov., 1928	No. 7 Frogs for Heavy Rails, Rail-Bound Manganese Steel, Bolted Rigid, Spring Rail, and Solid Manganese Steel	**Adopted Mar., 1929
275	Nov., 1928	No. 8 Frogs for Heavy Rails, Rail-Bound Manganese Steel, Bolted Rigid, Spring Rail, and Solid Manganese Steel	**Adopted Mar., 1929
276	Nov., 1928	No. 9 Frogs for Heavy Rails, Rail-Bound Manganese Steel, Bolted Rigid, Spring Rail, and Solid Manganese Steel.	**Adopted Mar., 1929
277	Nov., 1928	No. 10 Frogs for Heavy Rails, Rail-Bound Manganese Steel, Bolted Rigid, Spring Rail, and Solid Manganese Steel	**Adopted Mar., 1929
278	Nov., 1928	No. 11 Frogs for Heavy Rails, Rail-Bound Manganese Steel, Bolted Rigid, Spring Rail, and Solid Manganese Steel	**Adopted Mar., 1929
279	Nov., 1928	No. 12 Frogs for Heavy Rails, Rail-Bound Manganese Steel, Bolted Rigid, Spring Rail, and Solid Manganese Steel	**Adopted Mar., 1929

Frogs—Bolted Rigid

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
301	Sep. 15, 1919	No. 6 Bolted Rigid Frog	Adopted Mar., 1920
302	Sep. 15, 1919	No. 7 Bolted Rigid Frog	Adopted Mar., 1920
303	Sep. 15, 1919	No. 8 Bolted Rigid Frog	Adopted Mar., 1920
304	Sep. 15, 1919	No. 10 Bolted Rigid Frog	Adopted Mar., 1920
305	Sep. 15, 1919	Detail of Plates for No. 6, 7, 8 and 10 Bolted Rigid Frogs	Adopted Mar., 1920
306	Sep. 15, 1919	No. 11 Bolted Rigid Frog	Adopted Mar., 1920
307	Sep. 15, 1919	No. 16 Bolted Rigid Frog	Adopted Mar., 1920
308	Sep. 15, 1919	Detail of Plates for No. 11, 16 and 20 Bolted Rigid Frogs	Adopted Mar., 1920
309	Oct. 19, 1920	No. 4 and No. 5 Bolted Rigid Frogs	*Inform. Mar., 1921
320	Nov., 1920	Data for Laying Out Bolted Rigid Frogs	Adopted Mar., 1921
321	Nov., 1925	Tie Layout Standard Length Rigid Frogs for One-piece Guard Rail, 6 Ties, 19″ to 20″ Spacing, Suspended Joints.	*Inform. Mar., 1926
325	Nov., 1925	Frog Fillers for Rails 80 lb. per Yard and Heavier	*Inform. Mar., 1926

Also see plans listed under "FROGS—HEAVY RAIL"

The star (*) indicates the plan has been accepted as information only by the American Railway Engineering Association.
The double star (**) indicates plan recommended to be adopted Mar., 1929.



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NOVEMBER, 1928

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March, 1929

Frogs—Clamp

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
331	Sep. 15, 1919	No. 6 Clamp Frog	Adopted Mar., 1921
332	Sep. 15, 1919	No. 7 Clamp Frog	Adopted Mar., 1921
333	Sep. 15, 1919	No. 8 Clamp Frog	Adopted Mar., 1921
334	Sep. 15, 1919	No. 10 Clamp Frog	Adopted Mar., 1921
335	Sep. 15, 1919	Detail of Plates for No. 6, 7, 8 and 10 Clamp Frogs	Adopted Mar., 1921

Frogs—Bolted Rigid Self Guarded

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
341	Nov., 1928	No. 6 Bolted Rigid Self Guarded Frog	**Adopted Mar., 1929
342	Nov., 1928	No. 7 Bolted Rigid Self Guarded Frog	**Adopted Mar., 1929
343	Nov., 1928	No. 8 Bolted Rigid Self Guarded Frog	**Adopted Mar., 1929
344	Nov., 1928	No. 10 Bolted Rigid Self Guarded Frog	**Adopted Mar., 1929

Frogs—Diagrams of Preferred Names of Parts for Bolted Rigid and Clamp Frogs

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
390	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Bolted Rigid Frogs	Adopted Mar., 1921
391	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Clamp Frogs	Adopted Mar., 1921

Frogs—Spring Rail

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
401	Sep. 15, 1919	No. 10 Spring Rail Frog	Adopted Mar., 1920
402	Sep. 15, 1919	No. 8 Spring Rail Frog	Adopted Mar., 1920
403	Sep. 15, 1919	No. 11 Spring Rail Frog	Adopted Mar., 1920
404	Nov., 1923	No. 10 Spring Rail Frog for Rails $6\frac{1}{2}''$ High and Over	Adopted Mar., 1924
420	Nov., 1922	Data for Laying Out Spring Rail Frogs	Adopted Mar., 1923
490	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Spring Rail Frogs	Adopted Mar., 1921

Also see plans listed under "FROGS—HEAVY RAIL"

Guard Rails

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
501	Nov., 1920	Details of Guard Rails	Adopted Mar., 1921
502	Nov., 1920	Details of Guard Rail Fixtures	Adopted Mar., 1921
510	Nov., 1928	Manganese Steel One-piece Guard Rail on 6 Ties	*Inform. Mar., 1929
590	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Guard Rails	Adopted Mar., 1921

Frogs—Rail Bound Manganese Steel

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
600	Nov., 1927	Data for Laying Out Rail Bound Manganese Steel Frogs	Adopted Mar., 1928
601	Sep. 15, 1919	No. 6 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
602	Sep. 15, 1919	No. 7 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
603	Sep. 15, 1919	No. 8 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
604	Sep. 15, 1919	No. 10 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
605	Sep. 15, 1919	No. 11 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
606	Sep. 15, 1919	No. 16 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
607	Sep. 15, 1919	No. 20 Rail Bound Manganese Steel Frog	Adopted Mar., 1920
608	Oct. 19, 1920	No. 4 and No. 5 Rail Bound Manganese Steel Frogs	*Inform. Mar., 1921
609	Nov., 1927	Nos. 9, 12 and 14 Rail Bound Manganese Steel Frogs	Adopted Mar., 1928
610	Nov., 1927	Nos. 15 and 18 Rail Bound Manganese Steel Frogs	Adopted Mar., 1928

Also see plans listed under "FROGS—HEAVY RAIL"

Frogs—Solid Manganese Steel Self Guarded

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
640	Nov., 1928	Standard Dimensions for Solid Manganese Steel Self-Guarded Frogs	**Adopted Mar., 1929
643	Nov., 1928	No. 8 Self-Guarded Frog, Solid Manganese Steel	**Adopted Mar., 1929

Frogs—Solid Manganese Steel

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
651	Sep. 15, 1919	No. 6 Solid Manganese Steel Frog	Adopted Mar., 1920
652	Sep. 15, 1919	No. 7 Solid Manganese Steel Frog	Adopted Mar., 1920
653	Sep. 15, 1919	No. 8 Solid Manganese Steel Frog	Adopted Mar., 1920
654	Sep. 15, 1919	No. 10 Solid Manganese Steel Frog	Adopted Mar., 1920
655	Sep. 15, 1919	No. 11 Solid Manganese Steel Frog	Adopted Mar., 1920
656	Oct. 19, 1920	No. 4 and No. 5 Solid Manganese Steel Frogs	*Inform. Mar., 1921
670	Nov., 1928	Standard Dimensions for Solid Manganese Steel Frogs	**Adopted Mar., 1929

Also see plans listed under "FROGS—HEAVY RAIL"

Frogs—Diagrams of Preferred Names of Parts for Rail Bound and Solid Manganese Frogs

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
690	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Rail Bound Manganese Steel Frogs	Adopted Mar., 1921
691	Sep. 15, 1919	Diagram illustrating Preferred Names of Parts for Solid Manganese Steel Frogs	Adopted Mar., 1921

The star (*) indicates the plan has been accepted as information only by the American Railway Engineering Association
The double star (**) indicates plan recommended to be adopted Mar., 1929.

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Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
700	Nov., 1926	Application of Crossing Designs and Recommended Practices	Adopted Mar., 1927
700-A		Data and Record Sheet for Ordering Crossings	Adopted Mar., 1923
700-A	Example No. 1	Data and Record Sheet for Ordering Crossings	Adopted Mar., 1923
700-A	Example No. 2	Data and Record Sheet for Ordering Crossings	Adopted Mar., 1923
700-B	Nov., 1924	Data and Record Sheet for Ordering Compromise Joints	Adopted Mar., 1925
700-C	Nov., 1924	Data and Record Sheet for Ordering Compromise Rails	Adopted Mar., 1925

Bolted Rail Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
701	Oct., 1921	Three Rail Design—Angles 90° to 50°, inclusive	Adopted Mar., 1922
702	Oct., 1921	Two Rail Design—Angles 90° to 50°, inclusive	Adopted Mar., 1922
703	Oct., 1921	Three Rail Design—Angles below 50° to 35°, inclusive	Adopted Mar., 1922
704	Oct., 1921	Two Rail Design—Angles below 50° to 35°, inclusive	Adopted Mar., 1922
705	Oct., 1921	Three Rail Design—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
706	Oct., 1921	Two Rail Design—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
707	Oct., 1921	Single Rail Design and Two Rail Design with Short Easer Rails—Angles below 25° and above 14° 15′	Adopted Mar., 1922
708	Oct., 1921	Single Rail Design and Two Rail Design—Angles below 25° and above 14° 15′	Adopted Mar., 1922
709	Oct., 1921	Single Rail Design and Two Rail Design with Short Easer Rails—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
710	Oct., 1921	Single Rail Design and Two Rail Design—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922

Bolted Rail Crossings, Electric Railway over Steam Railroad

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
716	Nov., 1924	Bolted Rail Crossings, Steam Railroad over Electric Railway—Angles 90° to 50°, inclusive	Adopted Mar., 1925
717	Nov., 1924	Bolted Rail Crossings, Steam Railroad over Electric Railway—Angles below 50° to 30°, inclusive	Adopted Mar., 1925

Tie Layouts for Railroad Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
719-A	Nov., 1928	Tie Layout for Railroad Crossings, angles 8° 10′ to 14° 15′	**Adopted Mar., 1929
719-B	Nov., 1928	Tie Layout for Railroad Crossings, angles 14° 15′ to 25°	**Adopted Mar., 1929
719-C	Nov., 1928	Tie Layout for Railroad Crossings, angles 25° to 50°	**Adopted Mar., 1929
719-D	Nov., 1928	Tie Layout for Railroad Crossings, angles 50° to 90°	**Adopted Mar., 1929
720-A	Nov., 1926	Alternate Tie Layouts for Railroad Crossings, angles up to 90°	*Inform. Mar., 1927

Reinforced Concrete and Pile Crossing Foundations

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
721	Nov., 1927	Design of Reinforced Concrete and Pile Crossing Foundations	Adopted Mar., 1928

Manganese Steel Insert Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
751	Nov., 1920	Designs and Dimensions of Inserts, Detail A—Angles 45° to above 14° 15′	Adopted Mar., 1922
752	Nov., 1920	Designs and Dimensions of Inserts, Detail B—Angles 45° to above 14° 15′	Adopted Mar., 1922
753	Nov., 1920	Designs and Dimensions of Inserts—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
754	Oct., 1921	Three Rail Design, Detail A—Angles below 45° to 35°, inclusive	Adopted Mar., 1922
755	Oct., 1921	Two Rail Design, Detail A—Angles below 45° to 35°, inclusive	Adopted Mar., 1922
756	Oct., 1921	Three Rail Design, Detail A—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
757	Oct., 1921	Two Rail Design, Detail A—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
758	Oct., 1921	Two Rail Design with Short Easer Rails, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
759	Oct., 1921	Two Rail Design, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
760	Oct., 1921	Single Rail Design with Short Easer Rails, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
761	Oct., 1921	Single Rail Design, Detail A—Angles below 25° and above 14° 15′	Adopted Mar., 1922
762	Oct., 1921	Three Rail Design, Detail B—Angles below 45° to 35°, inclusive	Adopted Mar., 1922
763	Oct., 1921	Three Rail Design, Detail B—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
764	Oct., 1921	Two Rail Design with Short Easer Rails, Detail B—Angles below 35° to 25°, inclusive	Adopted Mar., 1922
765	Oct., 1921	Two Rail Design with Short Easer Rails, Detail B—Angles below 25° and above 14° 15′	Adopted Mar., 1922
766	Oct., 1921	Single Rail Design with Short Easer Rails, Detail B—Angles below 25° and above 14° 15′	Adopted Mar., 1922
767	Oct., 1921	Two Rail Design—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922
768	Oct., 1921	Single Rail Design—Angles 14° 15′ to 8° 10′, inclusive	Adopted Mar., 1922

Insulated Internal Joints

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
770	Nov., 1922	Insulated Internal Joint for Crossings, Three Rail Design—Angle below 45° to 25°, inclusive	*Inform. Mar., 1923

Solid Manganese Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
771	Nov., 1923	Solid Manganese Steel Crossings—Angles 90° to 60°, inclusive.	Adopted Mar. 1924
771-B	Nov., 1924	Solid Manganese Steel Crossings—Angles 90° to 60°, inclusive, Design No. 2 and Design No. 3, Alternates for Design detailed on Plan 771	*Inform. Mar., 1925
772	Nov., 1923	Solid Manganese Steel Crossings—Angles below 60° to 40°, inclusive	Adopted Mar., 1924
773	Nov., 1924	Solid Manganese Steel Crossings—Angles below 40° to 25°, inclusive	Adopted Mar., 1925
774	Nov., 1926	Solid Manganese Steel Crossing with interior connecting rails. Double Rail Construction—Angles below 25° and above 14° 15′	Adopted Mar., 1927
775	Nov., 1927	Solid Manganese Steel Crossing, with Interior Connecting Rails, Single Rail Construction—Angles, 14° 15′ to 8° 10′, incl.	Adopted Mar., 1928

The star (*) indicates the plan has been accepted as information only by the American Railway Engineering Association.
The double star (**) indicates plan recommended to be adopted Mar., 1929.

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Solid Manganese and Manganese Insert Crossings, Electric Railway over Steam Railroad

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
776	Nov., 1923	Solid Manganese Steel Crossings, Steam Railroad over Electric Railway—Angles 90° to 60°, inclusive	Adopted Mar., 1924
777	Nov., 1923	Solid Manganese Steel Crossings, Steam Railroad over Electric Railway—Angles below 60° to 40°, inclusive	Adopted Mar., 1924
778	Nov., 1925	Manganese Steel Insert Crossings, Steam Railroad over Electric Railway, Angles below 45° to 30° inclusive	Adopted Mar., 1926
780	Nov., 1926	Solid Manganese Steel Crossings, steam railroad over electric railway, for 7″ and 9″ girder rails, angles 90° to 60°, inclusive	Adopted Mar., 1927
781	Nov., 1926	Solid Manganese Steel Crossings, steam railroad over electric railway, for 7″ and 9″ girder rails, angles below 60° to 40°, inclusive	Adopted Mar., 1927

Tables for Gages and Flangeways

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
791	Nov., 1921	*Table No.* 1—Gages and Flangeways in Curved Track	Adopted Mar., 1922
792	Nov., 1921	*Table No.* 2—Gages and Flangeways in Curved Track—Gage Diagrams for Rigid Wheel Base Locomotives	Adopted Mar., 1922
793	Nov., 1928	A. R. A. Standard Wheel Flanges, Treads and Gages	*Inform. Mar., 1929

Double Slip Switches

Double Slip Switch Layouts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
801	Nov., 1922	No. 8 Double Slip Switch with Movable Center Points with Uniform Risers	Adopted Mar., 1923
802	Nov., 1922	No. 8 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1923
803	Nov., 1923	No. 10 Double Slip Switch with Movable Center Points with Uniform Risers	Adopted Mar., 1924
804	Aug., 1923	No. 10 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1924

Details of Double Slip Switches

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
851	Nov., 1922	Details of No. 8 Double Slip Switch with Movable Center Points Uniform Risers	Adopted Mar., 1923
852	Nov., 1922	Details of No. 8 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1923
853	Nov., 1923	Details of No. 10 Double Slip Switch with Movable Center Points with Uniform Risers	Adopted Mar., 1924
854	Aug., 1923	Details of No. 10 Double Slip Switch with Movable Center Points with Graduated Risers	Adopted Mar., 1924

Diagram of Preferred Names of Parts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
890	Nov., 1924	Diagram illustrating Preferred Names of Parts of Double Slip Switch with Movable Center Points	Adopted Mar., 1925

Turnouts and Crossovers

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
900	Nov., 1920	Table of Practical Turnout Leads *and* Table of Theoretical Turnout Leads	Adopted Mar., 1921

Turnout and Crossover Layouts

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
901	Sep. 20, 1920	Layout of No. 6 Turnout and Crossover	Adopted Mar., 1921
902	Sep. 20, 1920	Layout of No. 7 Turnout and Crossover	Adopted Mar., 1921
903	Sep. 20, 1920	Layout of No. 8 Turnout and Crossover with Rigid Frogs	Adopted Mar., 1921
904	Sep. 20, 1920	Layout of No. 8 Turnout and Crossover with Spring Frogs	Adopted Mar., 1921
905	Sep. 20, 1920	Layout of No. 10 Turnout and Crossover	Adopted Mar., 1921
906	Sep. 20, 1920	Layout of No. 11 Turnout and Crossover	Adopted Mar., 1921
907	Sep. 20, 1920	Layout of No. 16 Turnout and Crossover	Adopted Mar., 1921
908	Sep. 20, 1920	Layout of No. 20 Turnout and Crossover	Adopted Mar., 1921

Movable Point Crossings

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
951	Nov., 1926	Layout of No. 7 Movable Point Crossing	Adopted Mar., 1927
952	Nov., 1926	Details of Manganese Knuckle Rails and Details of Plates for No. 7 Movable Point Crossing	Adopted Mar., 1927
953	Nov., 1927	Details of Movable Points for Curved Crossings, angles 8° 10′ to 15° 30′ incl.	Adopted Mar., 1928
954	Nov., 1926	Details of Manganese Rail Bound Knuckle Rails for No. 8 and No. 10 slip switches	Adopted Mar., 1927
955	Nov., 1927	Details of Solid Manganese Steel Knuckle Rail for No. 8 and No. 10 Slip Switches	Adopted Mar., 1928

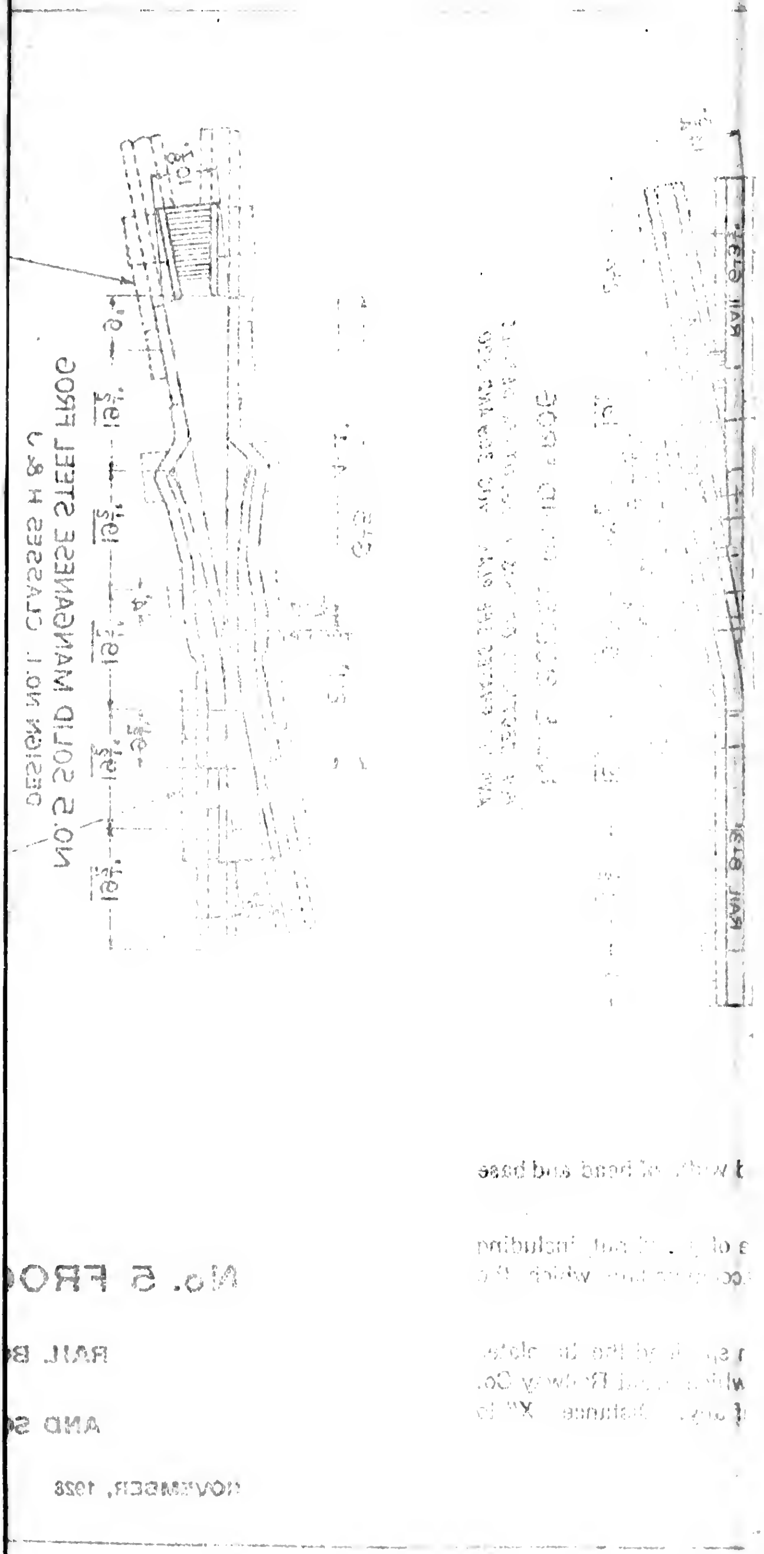
Track Construction for Paved Streets

PLAN No.	PLAN Date	TITLE	DATE OF ACCEPTANCE By A. R. E. A.
980	Nov., 1926	Alinement details for turnouts, tongue switch construction, for use in paved streets	Adopted Mar., 1927
983	Nov., 1927	Solid Manganese Steel Frogs for 7″ and 9″ Girder Rails	Adopted Mar., 1928
984	Nov., 1927	Nos. 4 and 5 Frogs, Iron Bound Manganese Steel Center, for 7″ and 9″ Girder Rails	Adopted Mar., 1928
985	Nov., 1927	Nos. 6 and 8 Frogs, Iron Bound Manganese Steel Center, for 7″ and 9″ Girder Rails	Adopted Mar., 1928
986	Nov., 1927	No. 10 Frog, Iron Bound Manganese Steel Center, for 7″ and 9″ Girder Rails	Adopted Mar., 1928

Specifications and Definitions

Appendix A	Specifications for the Design and Dimensions of Manganese Steel Pointed Switches	Adopted Mar., 1920
Appendix B	Specifications for Switches, Frogs, Crossings and Guard Rails	Adopted Mar., 1921
Appendix C	Definitions of Switch, Frog, Guard Rail, Crossing and Turnout Terms	Adopted Mar., 1924

The star (*) indicates the plan has been accepted as information only by the American Railway Engineering Association.
The double star (**) indicates plan recommended to be adopted Mar., 1929.



A. R. E. A. INDEX—SUPPLEMENT

March, 1929

Changes in Plans and Specifications listed in 1929 Index (Pages I, II III and IV) made since their last presentation.

Revisions to All Plans and Specifications

All future plans and specifications to have initials "A.R.E.A." that is, abbreviation for American Railway Engineering Association, placed thereon in a conspicuous manner, preferably above main title. Existing plans and specifications are to be modified in this respect only when reprinted.

Revisions to Plans Since Last Presentation

(This list includes revisions offered March, 1927, March, 1928 and March, 1929)

Nos. 301, 302, 303, 304, 306, and 309:

Add the following note: "This plan applies in all details only to frogs for rails having combined width of head and base 8⅝ in. or less and for rails not lighter than 80 lbs. per yard. For frogs for heavy rails see Plans 271 to 279 inclusive."

Omit physical test specifications for heat treated bolts, as these requirements are covered by Section 14, Specifications Appendix B, which supersede same.

Nos. 305, and 308:

Add the following note: "For tie layouts to accommodate one-piece guard rails requiring five tie spaces from 19 in. to 20 in., see Plan No. 321."

Also make the following change on these two plans: In section showing clip for fastening base plate change diameter of clip bolts from ⅞ in. to ¾ in.

Add the following note: "Lengths shown on this plan apply only to frogs for rails having combined width of head and base 8⅝ in. or less. For frogs for heavy rails see Plans 271 to 279 inclusive."

Nos. 307, 331, 332, 333, 334, and 501:

Omit physical test specifications for heat treated bolts, as these requirements are covered by Section 14, Specifications Appendix B, which supersede same.

Nos. 320, 321, and 420:

Add the following note: "Data shown on this plan apply only to frogs for rails having combined width of head and base 8⅝ in. or less. For frogs for heavy rails see Plans 271 to 279 inclusive."

Nos. 401, 402, and 403:

Omit physical test specifications for heat treated bolts, as these requirements are covered by Section 14, Specifications Appendix B, which supersede same.

Add the following note: "This plan applies in all details only to frogs for rails having combined width of head and base 8⅝ in. or less and for rails not lighter than 80 lbs. per yard. For frogs for heavy rails see Plans 271 to 279 inclusive."

No. 404:

Omit physical test specifications for heat treated bolts, as these requirements are covered by Section 14, Specifications Appendix B, which supersede same.

Add the following note: "Length, tie spacing, and bolt spacing shown on this plan not applicable to frogs for rails having combined width of head and base exceeding 8⅝ in. For No. 10 spring rail frog for heavy rails see Plan 277."

Nos. 601, 602, 603, 604, 605, and 609:

Add the following note: "Lengths shown on this plan apply only to frogs for rails having combined width of head and base 8⅝ in. or less. For frogs for heavy rails see Plans 273 to 279 inclusive."

No. 608:

In detail of heel rail change spread between gage lines at beginning of flare in manganese from 2¼ in. to 1⅝ in.

Add the following note: "Lengths shown on this plan apply only to frogs for rails having combined width of head and base 8⅝ in. or less. For frogs for heavy rails see Plans 271 and 272."

Nos. 651, 652, 653, 654, 655, and 656:

Add the following note "For heavy rail data and additional options, see Plan No. 670, revised November, 1928; also disregard tabulated heights and widths designated as 'Casting Data'." Also change second sentence of first paragraph under Notes to read: "Bolts to have button heads, oval necks, square nuts, and spring washers, unless otherwise specified or required." Add the following note: "This plan applies in all details only to frogs for rails having combined width of head and base 8⅝ in. or less. For dimensions and tie layouts for frogs for heavy rails see Plans 271 to 279 inclusive."

No. 700-A:

Under "Compromise Joints" in middle of sheet, change caption of first column to read "No. of Joints" instead of "No. of Pairs."

On right half of plan there are listed nine items of data to be shown on diagram; add a tenth item reading as follows:

"Tie layout, if crossing is to have base or tie plates."

Nos. 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 716, 717, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 771, 772, 774, 775, 776, 777 and 778.

Add the following note:

"For Application of A.R.E.A. Crossing Designs and Recommended Practices, see Plan No. 700, dated November, 1926."

No. 771-B:

Add the following note: "For application of A.R.E.A. Crossing Designs and Recommended Practices, see Plan No. 700, dated November, 1926."

Also in type A joint, change 5½ in. space to 6½ in. and show splice bar 31 in. long. In type B joint, show splice bar 31 in. long.

Also change first sentence of Note 6 to read:

"All special length splice bar bolts for connecting adjoining rails to be furnished with crossing and to have square nuts and spring washers unless otherwise specified or required."

No. 773:

Add the following note: "For Application of A.R.E.A. Crossing Designs and Recommended Practices, see Plan No. 700, dated November, 1926."

Also change last paragraph of specifications relating to special length splice bar bolts to read "All special length splice bar bolts for connecting adjoining rails shall be furnished with crossing, and to have square nuts and spring washers unless otherwise specified or required. Splice bars for connecting adjoining rails not to be furnished unless specified, or unless special bars are required."

No. 774:

Change title to read: "A.R.E.A. Solid Manganese Steel Crossing, with Interior Connecting Rails, Angles below 25° 00′ and above 14° 15′, Double Rail Construction."

Also change fourth paragraph under Notes to read:

"All special length splice bar bolts for connecting adjoining rails shall be furnished with crossing. Bolts to have button heads, oval necks, square nuts, and spring washers, unless otherwise specified or required."

Nos. 851, 852, 853, 854:

Add the following note:

"Details shown on this plan apply to rails less than 6½ in. high. For details for rail 6½ in. and higher, see Plans No. 205 to 208, inclusive."

No. 5 FROG

RAIL B

AND S

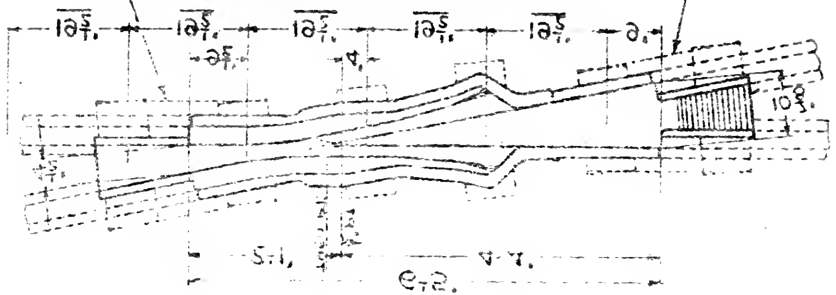
NOVEMBER, 1928

... width of head and base

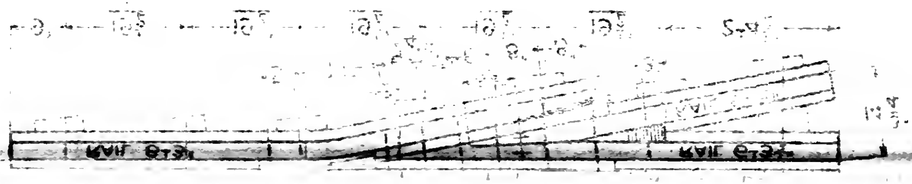
... e of guard rail, including
... accommodate which the

... specified the tie plates
... which event Railway Co.
... if any. Distance "X" to

NO. 5 SOLID MANGANESE STEEL FROG
DESIGN NO. 1. CLASSES H & J



NO. 5 BOLTED RIGID FROG
FOR SECTIONS OF THIS FROG, OTHER DETAILS
AND ALTERNATES SEE PLANS NOS. 309 AND 320



A. R. E. A. INDEX—SUPPLEMENT

March, 1929

Changes in Plans and Specifications listed in 1929 Index (Pages I, II, III and IV) made since their last presentation.

Revisions to Specifications for Switches, Frogs, Crossings and Guard Rails (Appendix B) Since Last Presentation

Change Section 33 to read:

"33. Gages and Flangeways.

"Track gage may be 1/8" under or 1/16" over that specified for managnese construction and 1/16" under or over for bolted construction.

"Guard gage (distance between guards) shall not exceed that specified but may be 1/8" less.

"The width of flangeways may not be less than specified nor more than 1/16" wider than specified.

"All the above measured on the level of gage line 5/8" below tread surface.

"Flangeways shall not be less than 1 7/8" deep measured from top of tread surfaces, unless otherwise specified."

Change Section 38 to read:

"38. Fit of Bolts. Main bolts (also referred to on plans as 'through' or 'body' bolts) in bolted rigid frogs and bolted rail crossings shall have a tight fit in straight, true holes. Heads and nuts shall have a square bearing. Other bolts not requiring a tight fit, unless otherwise specified, shall have a clearance of not more than 1/16 in. in drilled or punched holes and not more than 1/8 in. in cored holes. Holes in Solid Manganese Steel Frogs and Crossings to be 1/4 in. larger than bolt diameter as specified on plans. Threads must be U. S. Standard, accurately cut within tolerance of best practice for cut threads. Nuts must have a tight fit."

Change Section 47 to read:

"47. The acceptance of any material by an inspector shall not prevent subsequent rejection if found defective after delivery.

"No guarantee of specific length of service will be required. A claim for defective material and/or workmanship shall cover only such defects as will impair the life of the work.

"No claim for free replacement of defective material and/or workmanship shall be recognized unless made promptly and based on defects appearing within three months from date of installation and in any event within two years from date of shipment."

NOTE: Plans listed in this index, Pages I, II, III, IV, V and VI have been designed for standard tee rails of sections down to and including 80 lb. per yard in weight and for girder rails as noted.
They will not apply in all details for lighter section tee rails weighing less than 80 lb. per yard.

A. R. E. A.

SPECIFICATIONS FOR ADJUSTABLE RAIL BRACES

1. Braces shall be so designed that they can be readily applied with properly designed switch or tie plate and tie in position under the rail, and shall have a fit providing a bearing against two of the three rail surfaces (the web, under the head, and top of base) with a clearance between the brace and the edge of the base of rail.

2. Braces shall be provided with at least $\frac{3}{8}''$ adjustment in increments not greater than $\frac{1}{16}''$. Bearing on the rail and shoulder of plate not to be reduced by adjustment.

3. Braces to be secured to the plate with at least two heat treated bolts having a diameter of not less than $\frac{7}{8}''$, provided with spring washers, or other approved detail of equal strength. These bolts to extend either through the tie or through the plate only, in which latter case means shall be provided to prevent either the bolt heads or nuts from turning. These bolts shall be located close to the edge of the base of the stock rail so as to provide a maximum hold down effect.

4. Braces shall be made of copper bearing mild steel, malleable iron or cast steel.

A. R. E. A.

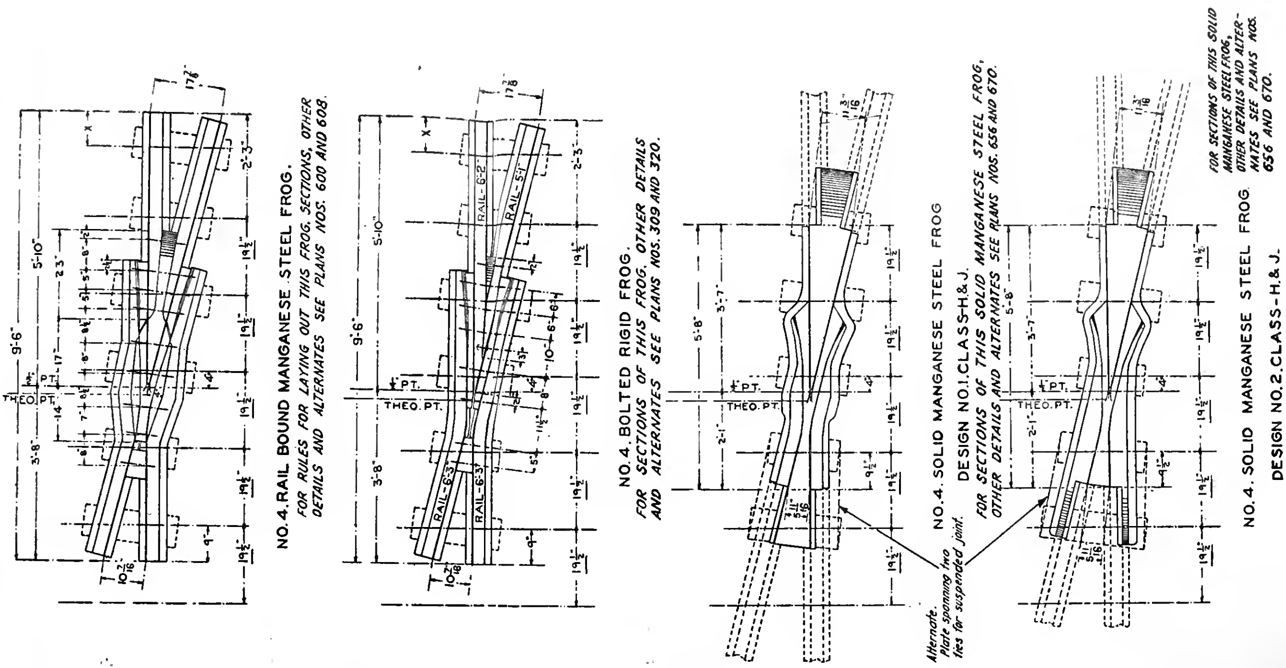
SPECIFICATIONS FOR

ADJUSTABLE RAIL BRACES

NOVEMBER, 1928

PLAN No. 240

29



NOTES:

Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝" but not exceeding 9¹³⁄₁₆").

The uniform tie layout shown is suitable for any type of guard rail, including six-tie one-piece designs with spacing 19" to 20", to accommodate which the distances underlined thus (19½") must be adhered to.

The use of plates on all ties is recommended. When specified the tie plates shown in dotted lines shall be furnished with frog, in which event Railway Co. shall supply details of splice bars showing spike slotting, if any. Distance "X" to suit spike slotting.

For specifications see Appendix "B"

A. R. E. A.

No. 4 FROGS FOR HEAVY RAILS

ANGLE 14°-15'-00"

RAIL BOUND MANGANESE STEEL

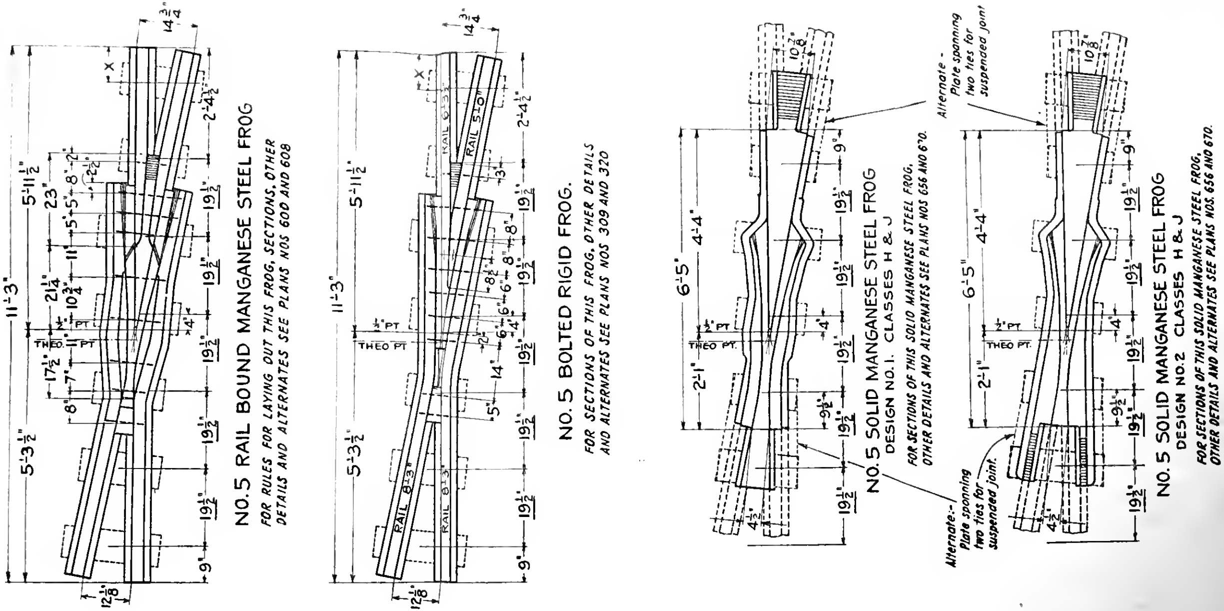
BOLTED RIGID

AND SOLID MANGANESE STEEL

NOVEMBER, 1928

PLAN No. 271

29



NOTES:

Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝″ but not exceeding 9$^{13}/_{16}$″).

The uniform tie layout shown is suitable for any type of guard rail, including six-tie one-piece designs with spacing 19″ to 20″, to accommodate which the distances underlined thus (19½″) must be adhered to.

The use of plates on all ties is recommended. When specified the tie plates shown in dotted lines shall be furnished with frog, in which event Railway Co. shall supply details of splice bars showing spike slotting, if any. Distance "X" to suit spike slotting.

For specifications see Appendix "B"

A. R. E. A.

No. 5 FROGS FOR HEAVY RAILS

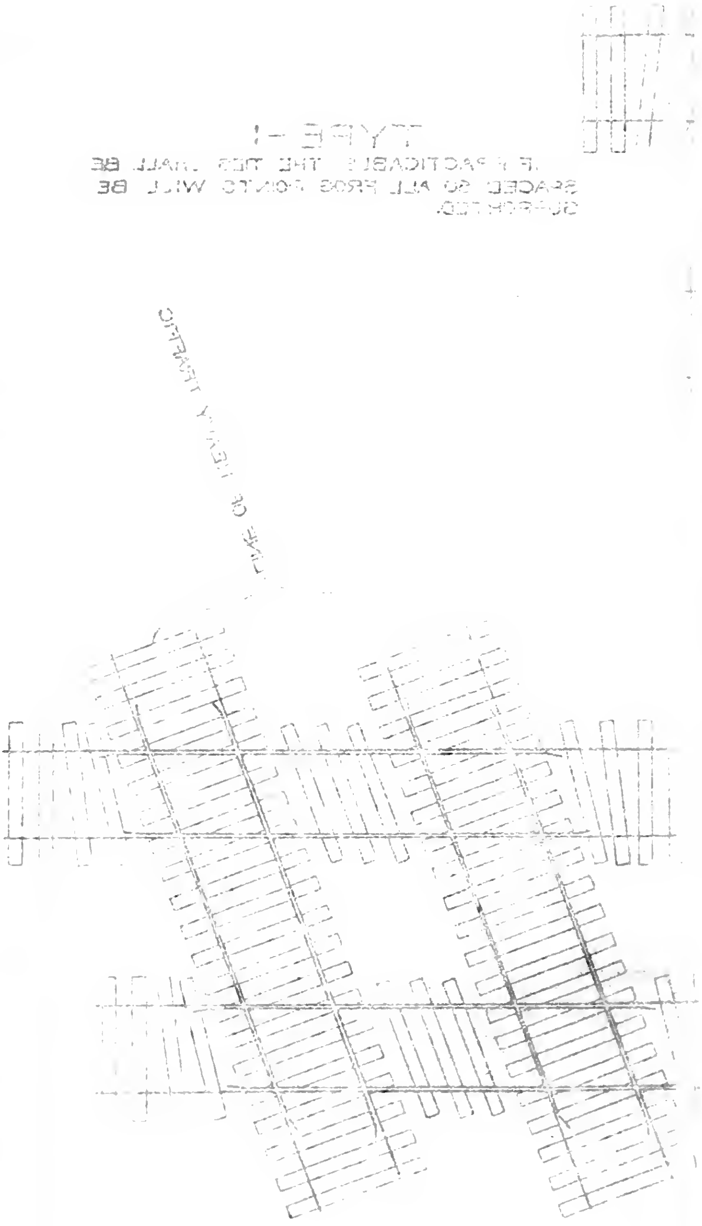
ANGLE 11°-25′-16″

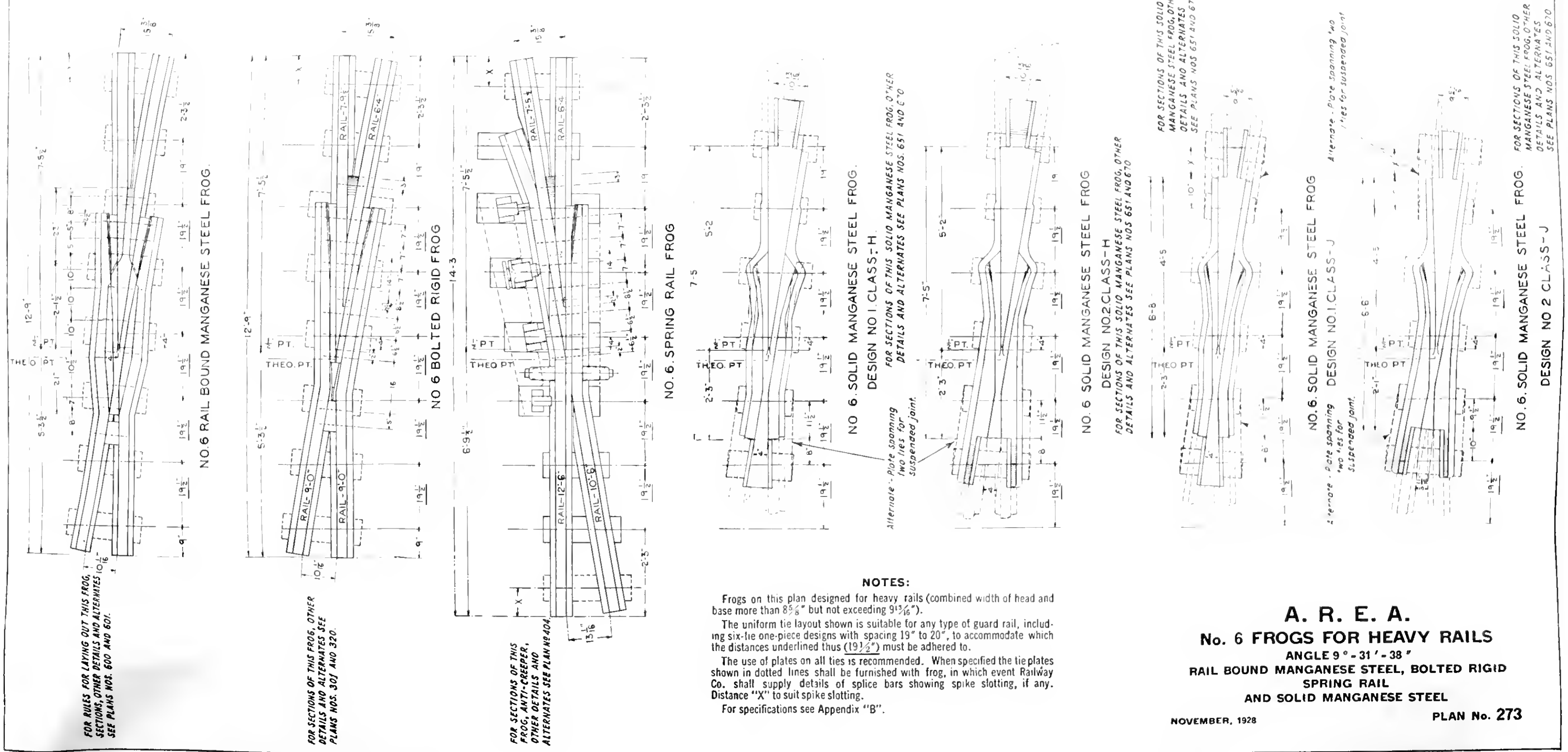
RAIL BOUND MANGANESE STEEL

BOLTED RIGID

AND SOLID MANGANESE STEEL

NOVEMBER, 1928 **PLAN No. 272**





NOTES:

Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝" but not exceeding 9¹³⁄₁₆").

The uniform tie layout shown is suitable for any type of guard rail, including six-tie one-piece designs with spacing 19" to 20", to accommodate which the distances underlined thus (19½") must be adhered to.

The use of plates on all ties is recommended. When specified the tie plates shown in dotted lines shall be furnished with frog, in which event Railway Co. shall supply details of splice bars showing spike slotting, if any. Distance "X" to suit spike slotting.

For specifications see Appendix "B".

A. R. E. A.

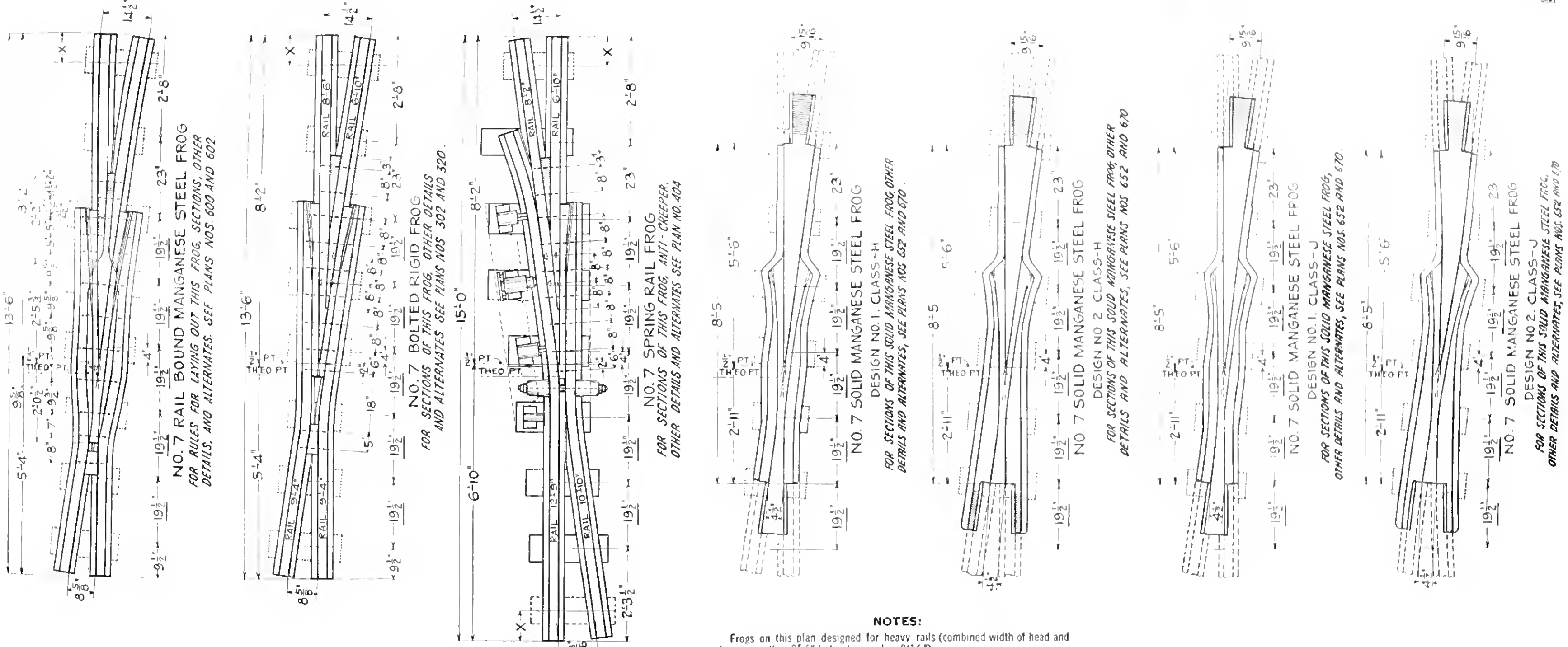
No. 6 FROGS FOR HEAVY RAILS

ANGLE 9°-31'-38"

RAIL BOUND MANGANESE STEEL, BOLTED RIGID SPRING RAIL AND SOLID MANGANESE STEEL

NOVEMBER, 1928

PLAN No. 273



NOTES:

Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝" but not exceeding 9¹³⁄₁₆").

The uniform tie layout shown is suitable for any type of guard rail, including six-tie one piece designs with spacing 19" to 20", to accommodate which the distances underlined thus (19½") must be adhered to.

The use of plates on all ties is recommended. When specified the tie plates shown in dotted lines shall be furnished with frog, in which event Railway Co. shall supply details of splice bars showing spike slotting, if any. Distance "X" to suit spike slotting

For specifications see Appendix "B".

A. R. E. A.

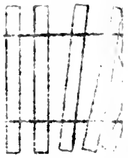
No. 7 FROGS FOR HEAVY RAILS

ANGLE 8° - 10' - 16"

RAIL BOUND MANGANESE STEEL, BOLTED RIGID SPRING RAIL AND SOLID MANGANESE STEEL

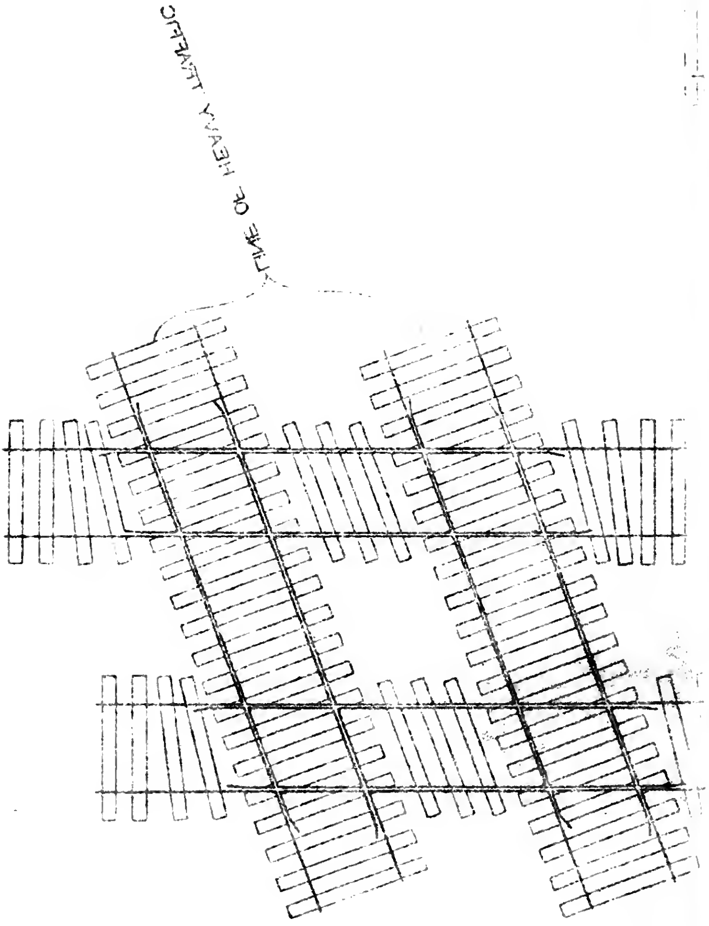
NOVEMBER, 1928

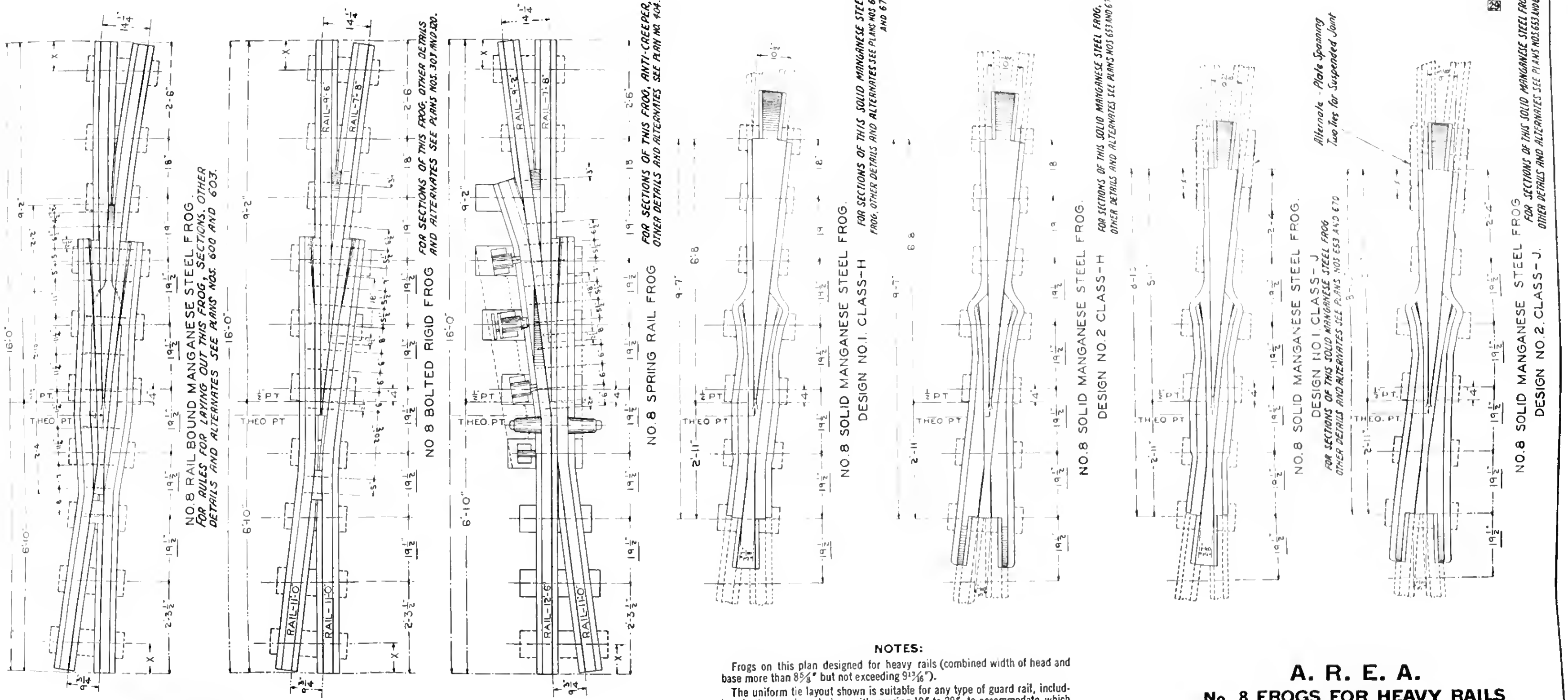
PLAN No. 274



TYPE-I

IF PRACTICABLE THE TIES SHALL BE SPACED SO ALL FROG POINTS WILL BE SUPPORTED.





NOTES:

Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝" but not exceeding 9¹³⁄₁₆").

The uniform tie layout shown is suitable for any type of guard rail, including six-tie one-piece designs with spacing 19" to 20", to accommodate which the distances underlined thus (19½") must be adhered to.

The use of plates on all ties is recommended. When specified the tie plates shown in dotted lines shall be furnished with frog, in which event Railway Co. shall supply details of splice bars showing spike slotting, if any. Distance "X" to suit spike slotting.

For specifications see Appendix "B".

A. R. E. A.

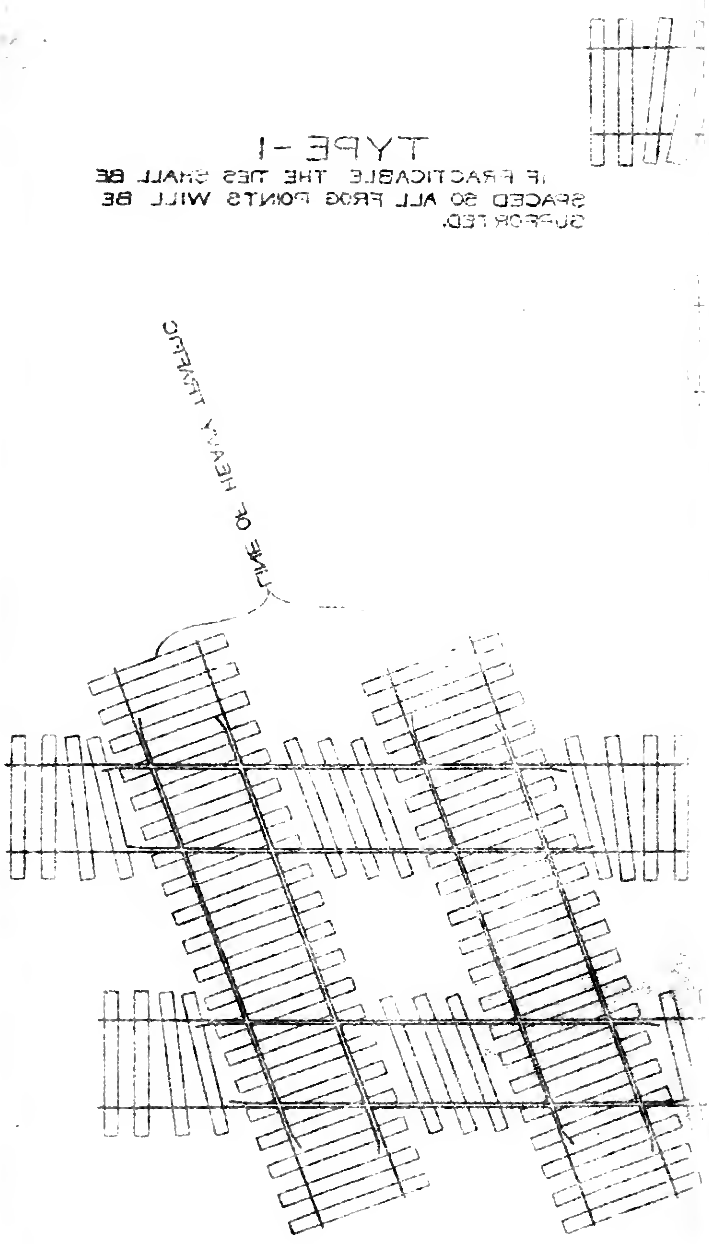
No. 8 FROGS FOR HEAVY RAILS

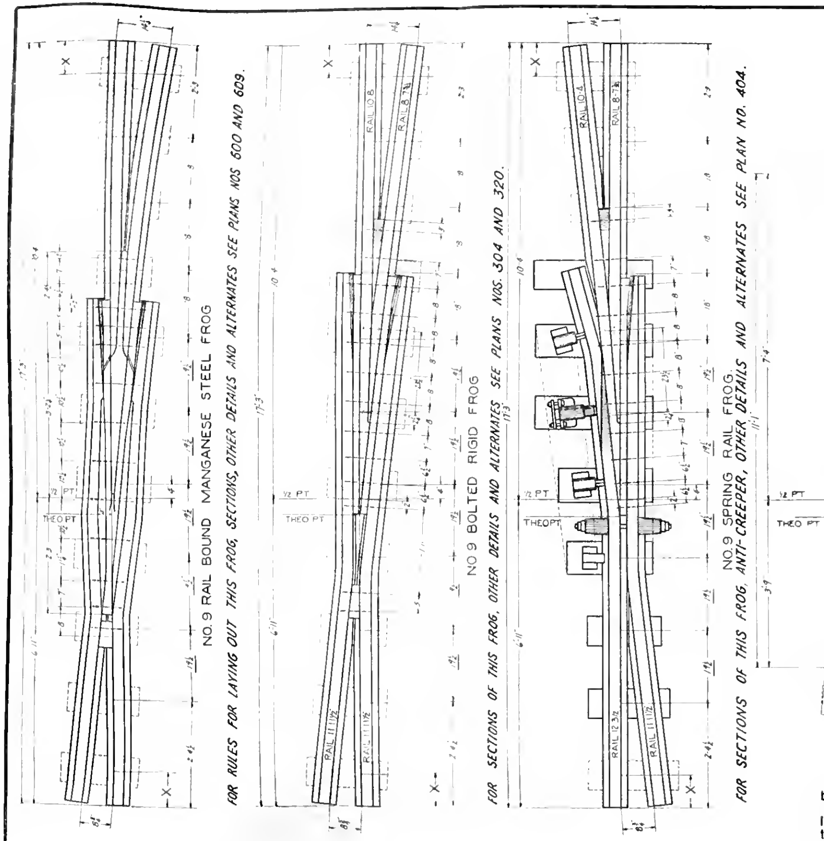
ANGLE 7°-09′-10″

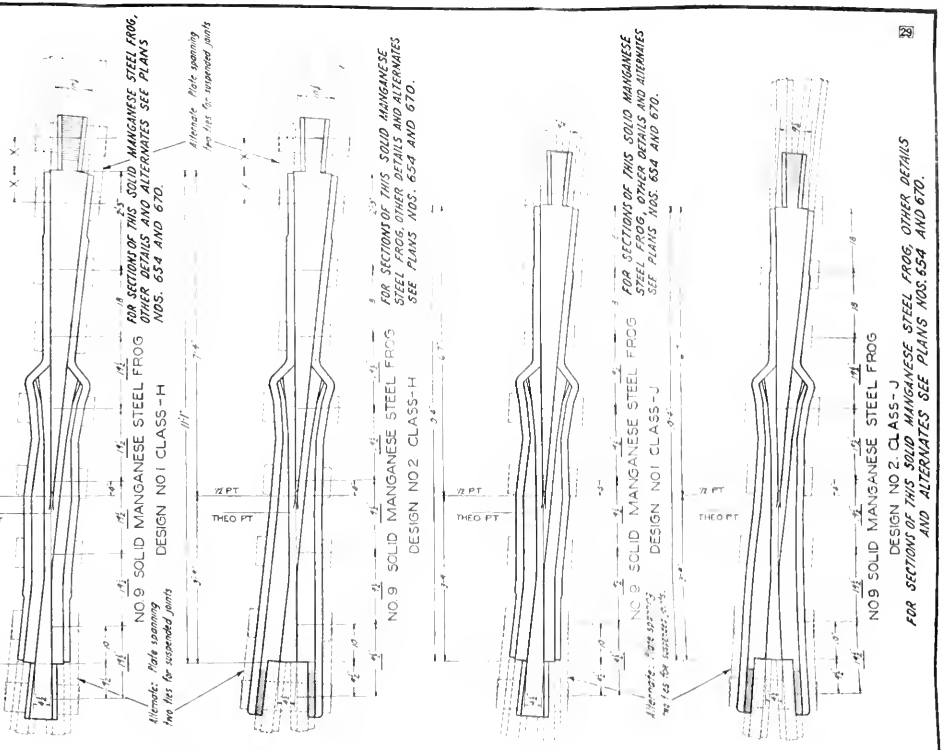
RAIL BOUND MANGANESE STEEL, BOLTED RIGID SPRING RAIL AND SOLID MANGANESE STEEL

NOVEMBER, 1928

PLAN No. 275


TYPE-1
IF PRACTICABLE THE TIES SHALL BE SPACED SO ALL FROG POINTS WILL BE SUPPORTED.
LINE OF HEAVY TRAFFIC





NOTES:

Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝" but not exceeding 9¹³⁄₁₆").

The uniform tie layout shown is suitable for any type of guard rail, including six-tie one-piece desiens with spacing 19" to 20", to accommodate which the distances underlined thus (19½") must be adhered to.

The use of plates on all ties is recommended. When specified the tie plates shown in dotted lines shall be furnished with frog, in which event Railway Co. shall supply details of splice bars showlng spike slotting, if any. Distance "X" to suit spike slotting.

For specifications see Appendix "B"

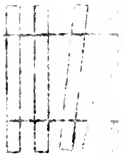
A. R. E. A.

No. 9 FROGS FOR HEAVY RAILS

ANGLE 6°-21'-35"

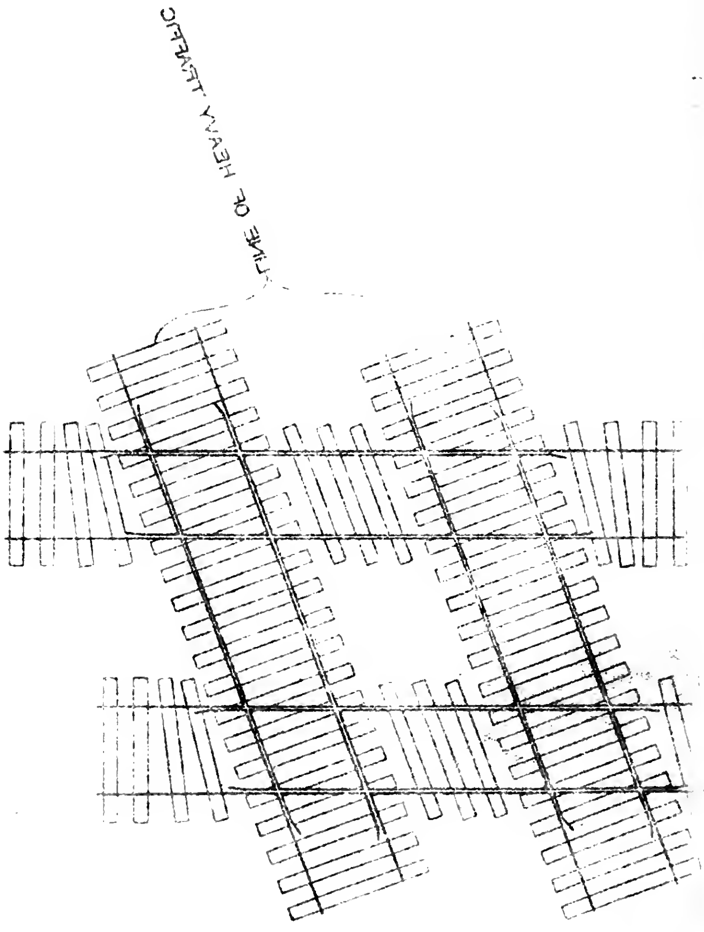
RAIL BOUND MANGANESE STEEL, BOLTED RIGID
SPRING RAIL
AND SOLID MANGANESE STEEL

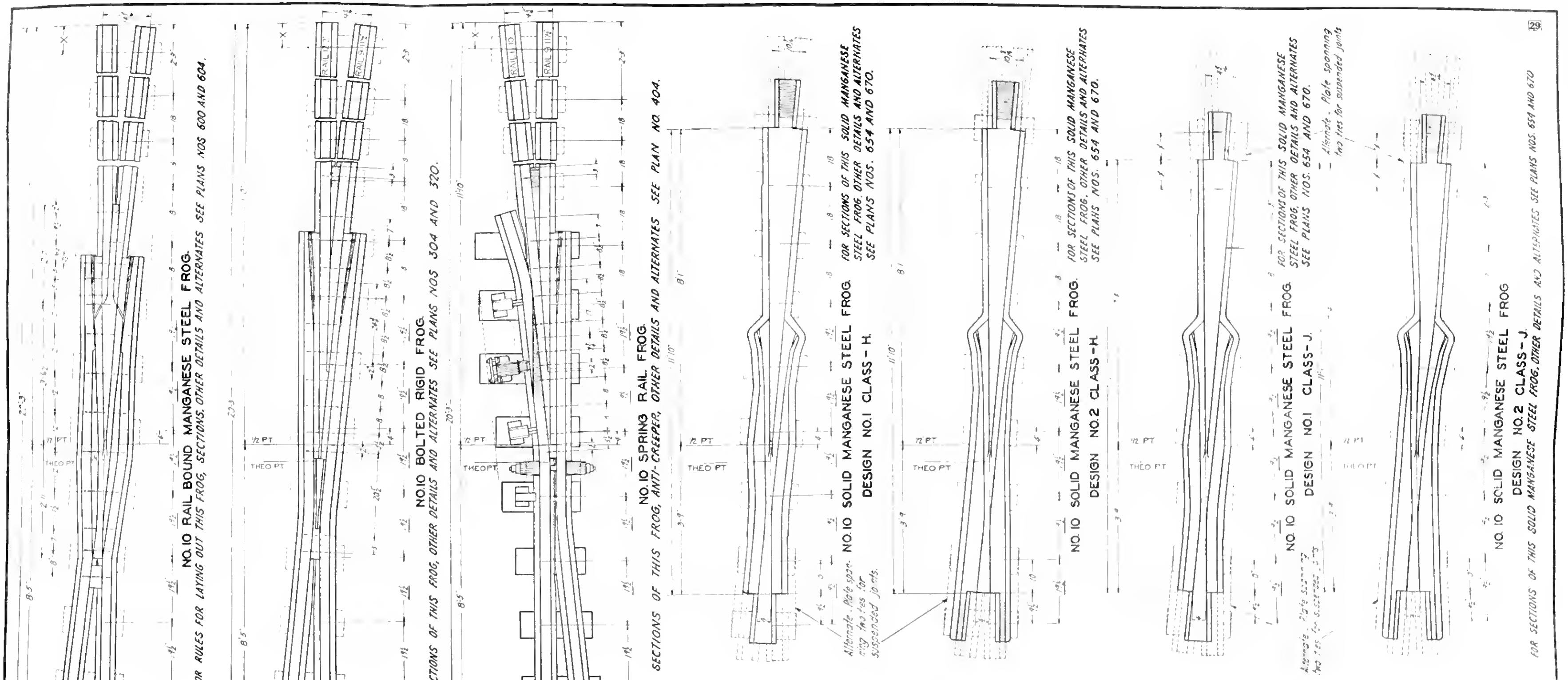
NOVEMBER, 1929 PLAN No. 276



TYPE-I

IF PRACTICABLE THE TIES SHALL BE
SPACED SO ALL FROG POINTS WILL BE
SUPPORTED.





NOTES:

Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝" but not exceeding 9¹³⁄₁₆").

The uniform tie layout shown is suitable for any type of guard rail, including six-tie one-piece designs with spacing 19" to 20", to accommodate which the distances underlined thus (19½") must be adhered to.

The use of plates on all ties is recommended. When specified the tie plates shown in dotted lines shall be furnished with frog in which event Railway Co. shall supply details of splice bars showing spike slotting, if any. Distance "X" to suit spike slotting.

For specifications see Appendix "B"

A. R. E. A.

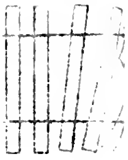
No. 10 FROGS FOR HEAVY RAILS

ANGLE 5° - 43' - 29"

RAIL BOUND MANGANESE STEEL, BOLTED RIGID SPRING RAIL AND SOLID MANGANESE STEEL

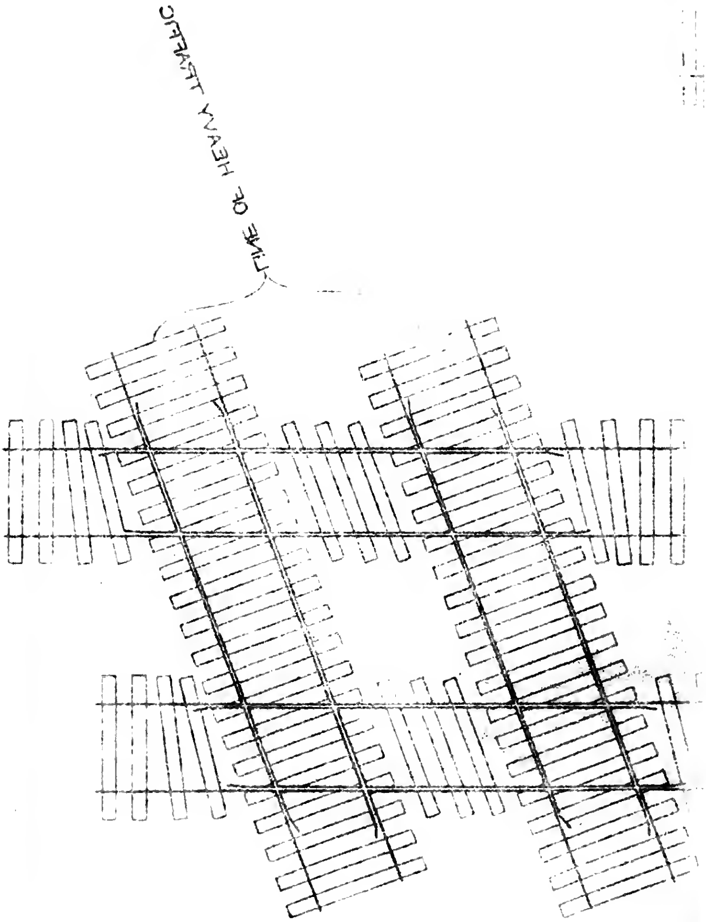
NOVEMBER, 1928

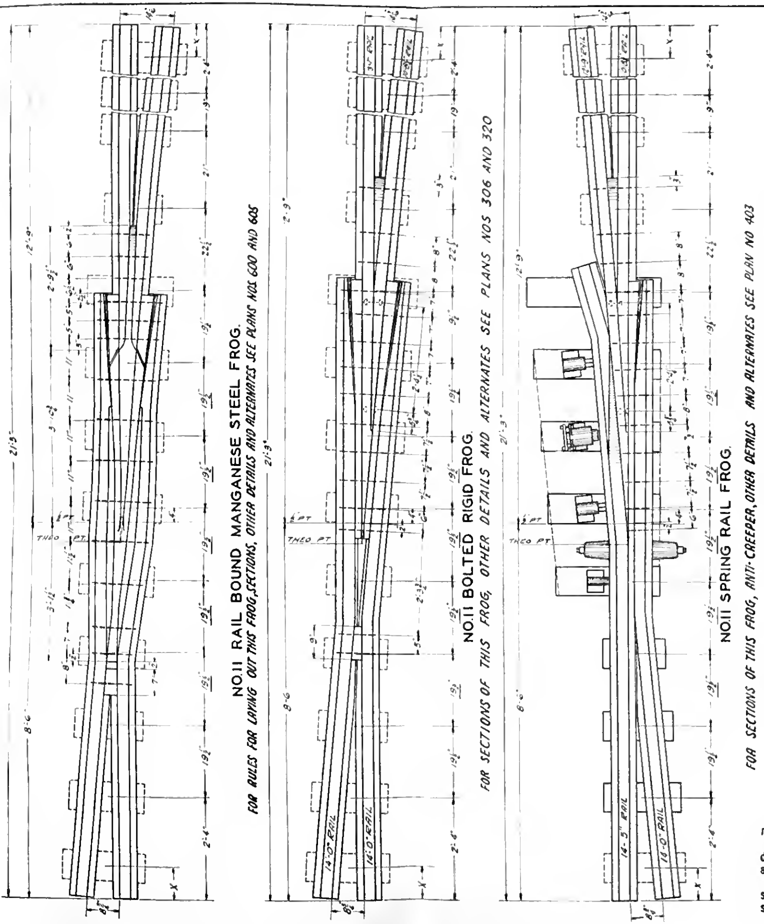
PLAN No. 277

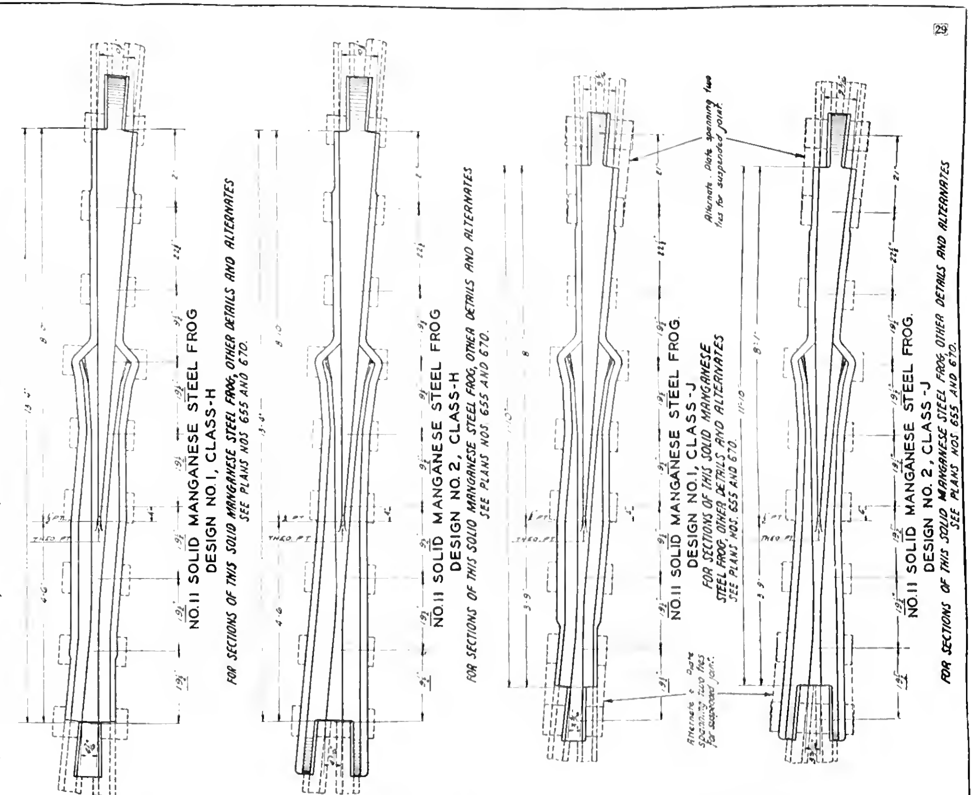


TYPE-I

IF PRACTICABLE THE TIES SHALL BE SPACED SO ALL FROG POINTS WILL BE SUPPORTED.







NOTES:

Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝" but not exceeding 9¹³⁄₁₆").

The uniform tie layout shown is suitable for any type of guard rail, including six-tie one-piece designs with spacing 19" to 20", to accommodate which the distances underlined thus (19½") must be adhered to.

The use of plates on all ties is recommended. When specified the tie plates shown in dotted lines shall be furnished with frog in which event Railway Co. shall supply details of splice bars showing spike slotting, if any. Distance "X" to suit spike slotting.

For specifications see Appendix "B".

A. R. E. A.

No. 11 FROGS FOR HEAVY RAILS

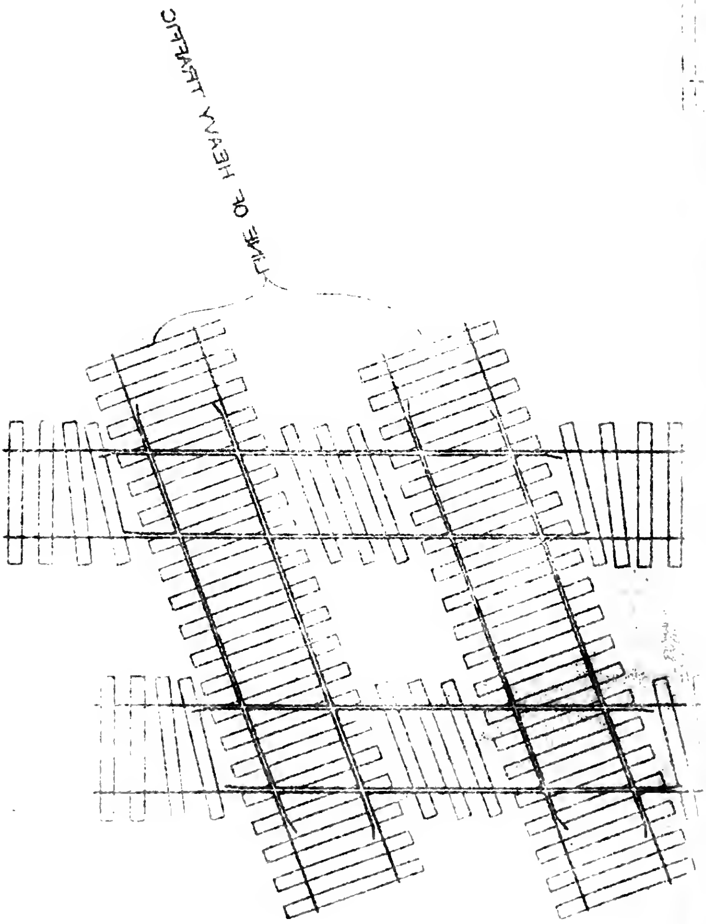
ANGLE 5° - 12' - 18"

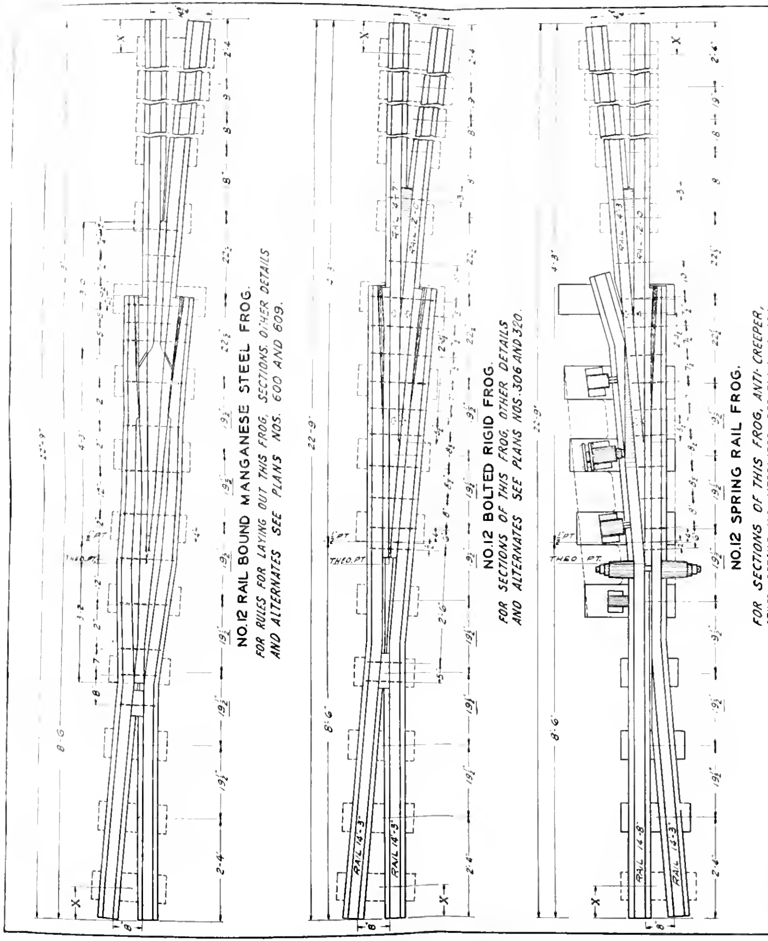
RAIL BOUND MANGANESE STEEL, BOLTED RIGID SPRING RAIL AND SOLID MANGANESE STEEL

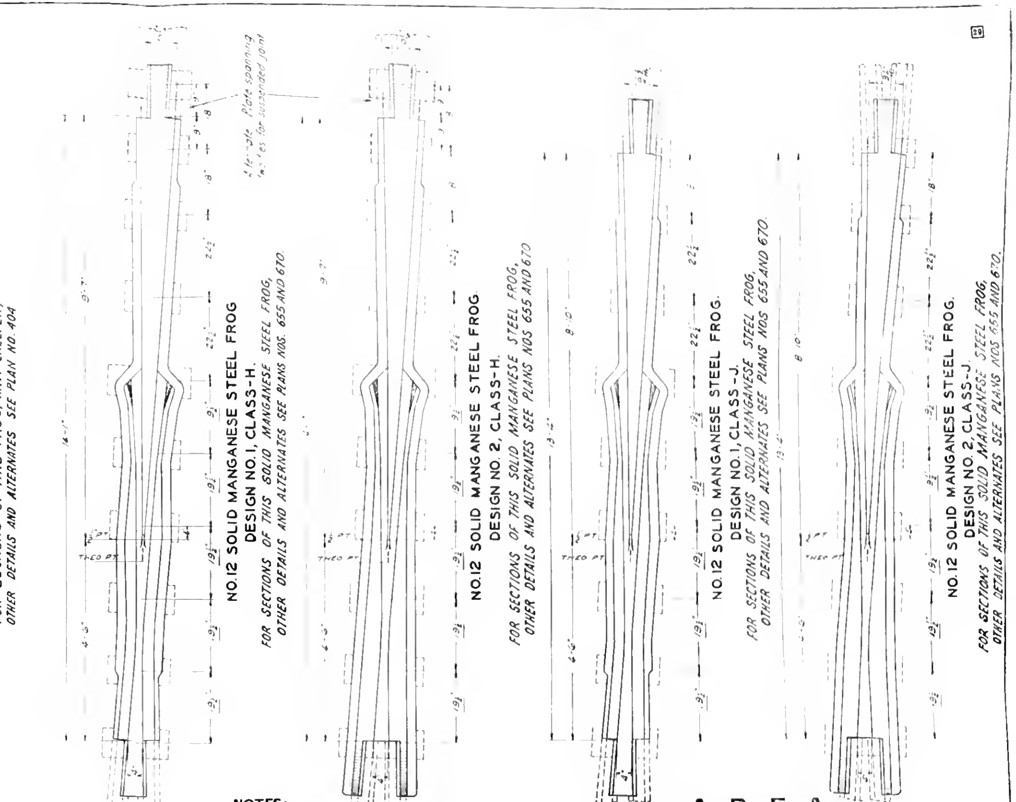
NOVEMBER, 1928 — **PLAN No. 278**

TYPE-I

IF PRACTICABLE THE TIES SHALL BE SPACED SO ALL FROG POINTS WILL BE SUPPORTED.







NOTES:

Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝" but not exceeding 9¹³⁄₁₆").

The uniform tie layout shown is suitable for any type of guard rail, including six-tie one-piece designs with spacing 19" to 20", to accommodate which the distances underlined thus (19½") must be adhered to.

The use of plates on all ties is recommended. When specified the tie plates shown in dotted lines shall be furnished with frog, in which event Railway Co. shall supply details of splice bars showing spike slotting, if any. Distance "X" to suit spike slotting.

For specifications see Appendix "B"

A. R. E. A.

No. 12 FROGS FOR HEAVY RAILS

ANGLE 4° - 46' - 19"

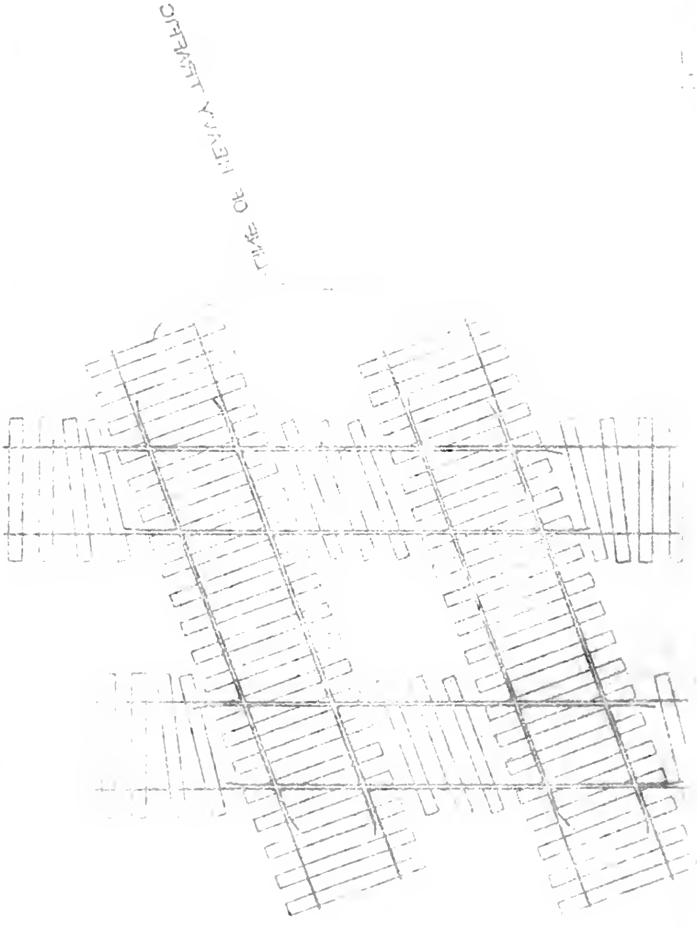
RAIL BOUND MANGANESE STEEL, BOLTED RIGID SPRING RAIL AND SOLID MANGANESE STEEL

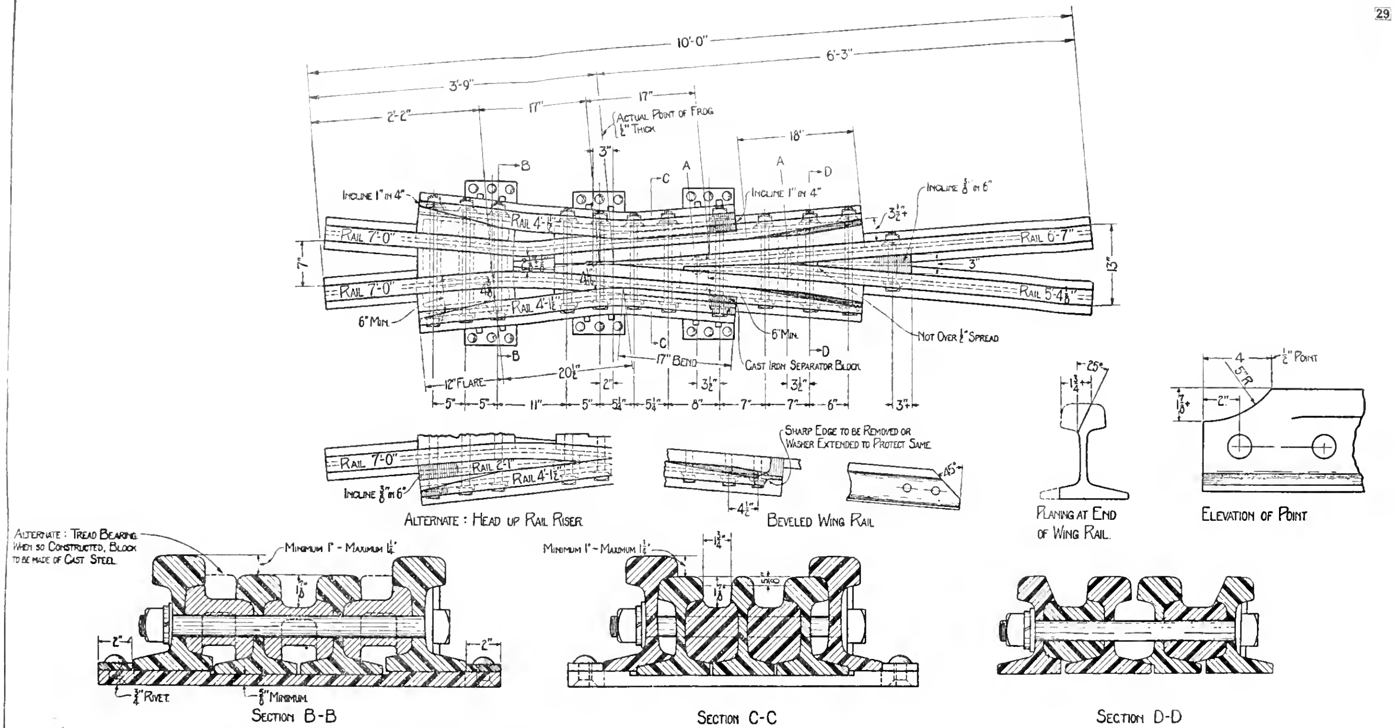
NOVEMBER, 1928

PLAN No. 279

TYPE-I

IF PRACTICABLE THE TIES SHALL BE SPACED SO ALL FROG POINTS WILL BE SUPPORTED.





SPECIFICATIONS

Details shown on this plan apply for rails less than 6½" high, and for rails whose combined width of head and base does not exceed 8⅝".

BOLTS—Through bolts 1⅜" dia. for 120 lb. rail and heavior.
1¼" dia. bolts for rails less than 120 lb. and down to rails having 3" fishing height.
1⅛" dia. bolts for rails having less than 3" fishing height, down to and including 80 lb. rail.
Fishing height shall be measured on vertical center line of rail.
All through bolts, including those in heel riser block, to be heat treated steel.
See Specifications, Appendix B.
All through bolts to have extra thick nuts and tight fit except thru castings.
Through bolts to have square heads and nuts with U. S. Standard thread fitted with head locks, nut locks, and bevel washers where necessary to afford square bearing.
Suitable washers in any case shall be placed under nuts to bring same out from under head of rail, so that they may be tightened with standard wrench.

FILLERS—Filler blocks shall fit the fishing angles and the web of rail for a distance of ½" from above and below the base and head respectively and shall maintain the required flangeway.
Throat filler block, point separator blocks and taper and elevation blocks shall be of good quality cast iron.
Body filler blocks shall be of rolled steel in one continuous length, either single or double groove section, or of good quality grey cast iron when specified, in which case they shall be furnished of single groove section and in three lengths with open spaces A as indicated by dotted lines.

HEEL RISER—Heel riser shall be of steel rail, head up with flange upset to properly fit over and rest upon bases of adjoining rails or of other approved design that will insure a proper bearing on the bases of the heel rails and will provide rolled or forged steel wearing surface equal in hardness to rail steel.

RIVETS—Rivets through point rails shall be ¼" less in diameter than the through bolts. They may be countersunk.
If either button or cone head rivets are used, filler blocks must be cut out to clear.

PLATES—When additional bearing plates are required they shall be as per plan No. 305

LENGTHS—Lengths of frogs overall shall not vary more than ½" from length specified. Frogs may be furnished to modified lengths to meet alignment of track or local conditions when specified.

FOOT GUARDS—Additional foot guarding to that shown in plan view to be furnished when so specified.

BEVELED ENDS OF WING RAILS—Flared ends of wing rails may be beveled on an angle of 45° as per detail when so specified.

A. R. E. A.

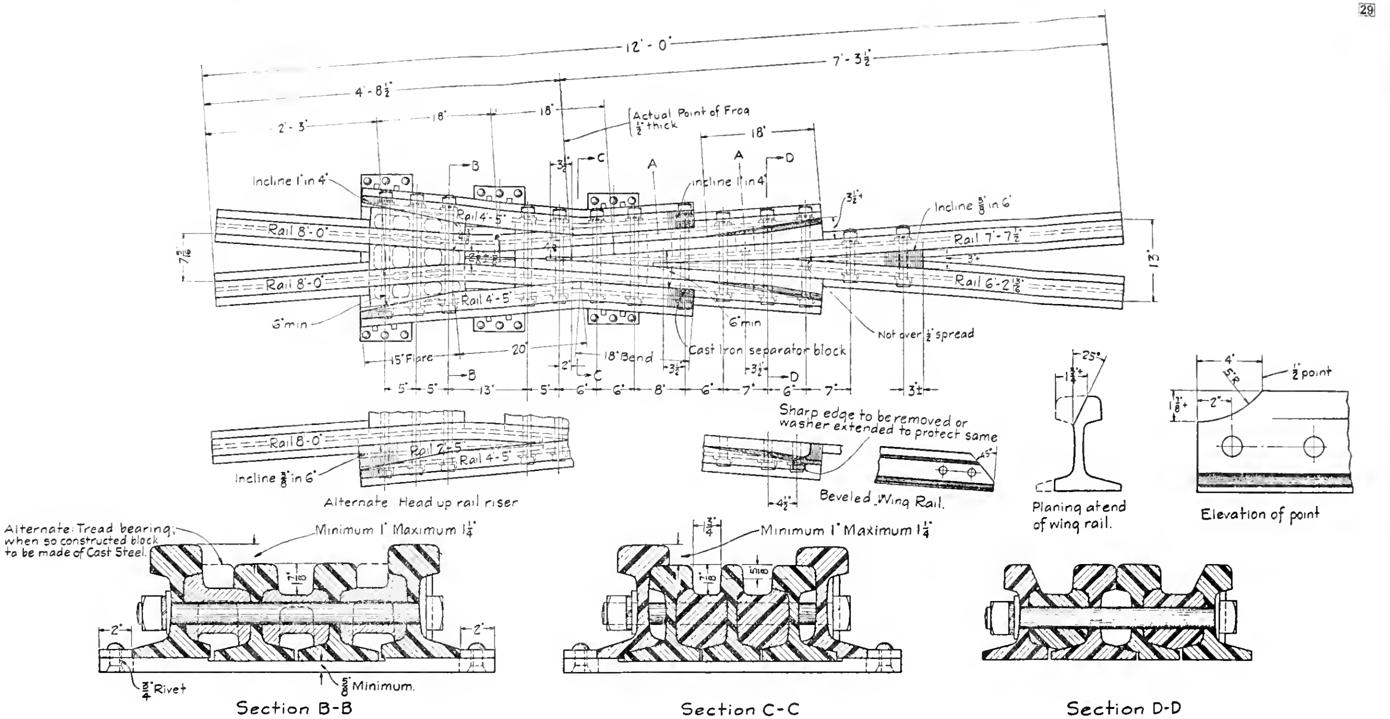
NO. 6 SELF GUARDED FROG BOLTED RIGID TYPE

ANGLE 9°31′38″

NOVEMBER, 1928

PLAN No. 341

29



SPECIFICATIONS

Details shown on this plan apply for rails less than 6½" high, and for rails whose combined width of head and base does not exceed 8⅝"

BOLTS—Through bolts 1⅜" dia. for 120 lb. rail end heavier.
1¼" dia. bolts for rails less than 120 lb. and down to rails having 3" fishing height.
1⅛" dia. bolts for rails having less than 3" fishing height, down to and including 80 lb. rail.
Fishing height shall be measured on vertical center line of rail.
All through bolts, including those in heel riser block, to be heat treated steel.
See Specifications, Appendix B.
All through bolts to have extra thick nuts end tight fit except thru castings.
Through bolts to have square heads and nuts with U. S. Standard thread fitted with head locks, nut locks, and bevel washers where necessary to afford square bearing.
Suitable washers in any case shall be placed under nuts to bring same out from under head of rail, so that they may be tightened with standard wrench.

FILLERS—Filler blocks shall fit the fishing angles and the web of rail for a distence of ½" from above and below the base and head respectively and shall maintain the required flangeway.
Throat filler block, point separator blocks and taper and elevation blocks shall be of good quality cast iron.
Body filler blocks shall be of rolled steel in one continuous length, either single or double groove section, or of good quality grey cast iron when specified, in which case they shall be furnished of single groove section and in three lengths with open spaces A as indicated by dotted lines.

HEEL RISER—Heel riser shall be of steel rail, head up with flange upset to properly fit over and rest upon bases of adjoining rails or of other approved design that will insure a proper bearing on the bases of the heel rails and will provide rolled or forged steel wearing surface equal in hardness to rail steel.

RIVETS—Rivets through point rails shall be ¼" less in diameter than the through bolts. They may be countersunk.
If either button or cone head rivets are used, filler blocks must be cut out to clear.

PLATES—When additional bearing plates are required they shall be as per plan No. 305

LENGTHS—Lengths of frogs overall shall not vary more than ½" from length specified. Frogs may be furnished to modified lengths to meet alignment of track or local conditions when specified.

FOOT GUARDS—Additional foot guarding to that shown in plan view to be furnished when so specified.

BEVELED ENDS OF WING RAILS—Flared ends of wing rails may be beveled on an angle of 45° as per detail when so specified.

A.R.E.A.

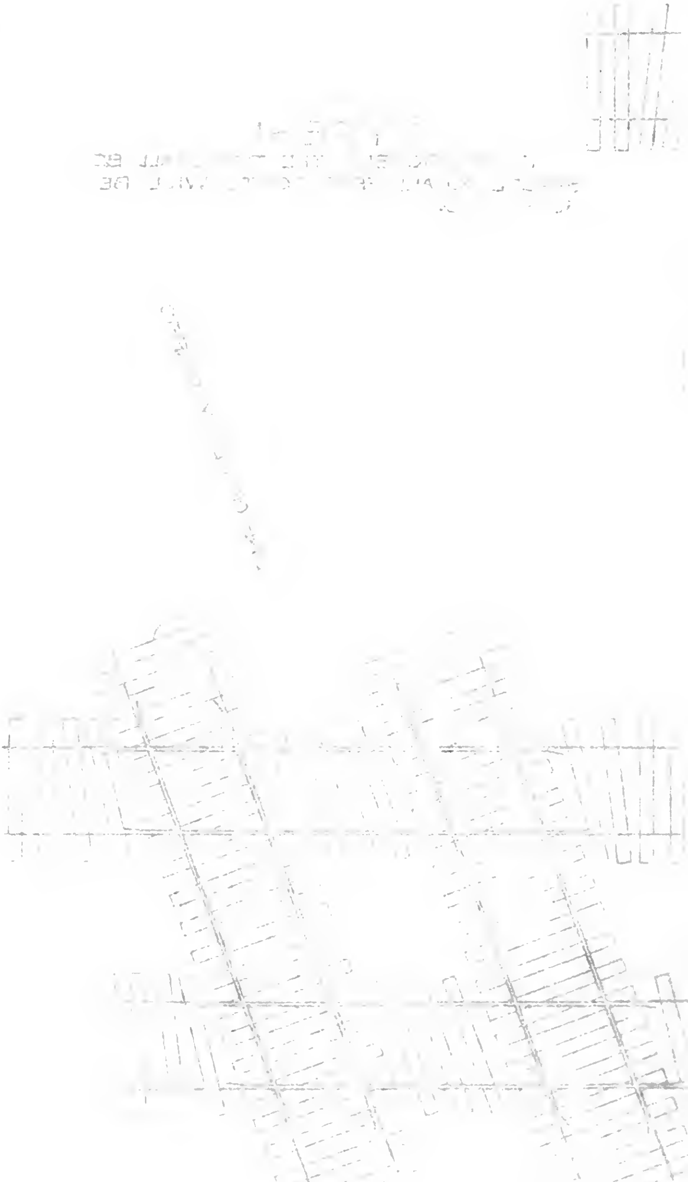
NO. 7 SELF GUARDED FROG

BOLTED RIGID TYPE

ANGLE 8° 10' 16"

NOVEMBER, 1928

PLAN No. 342



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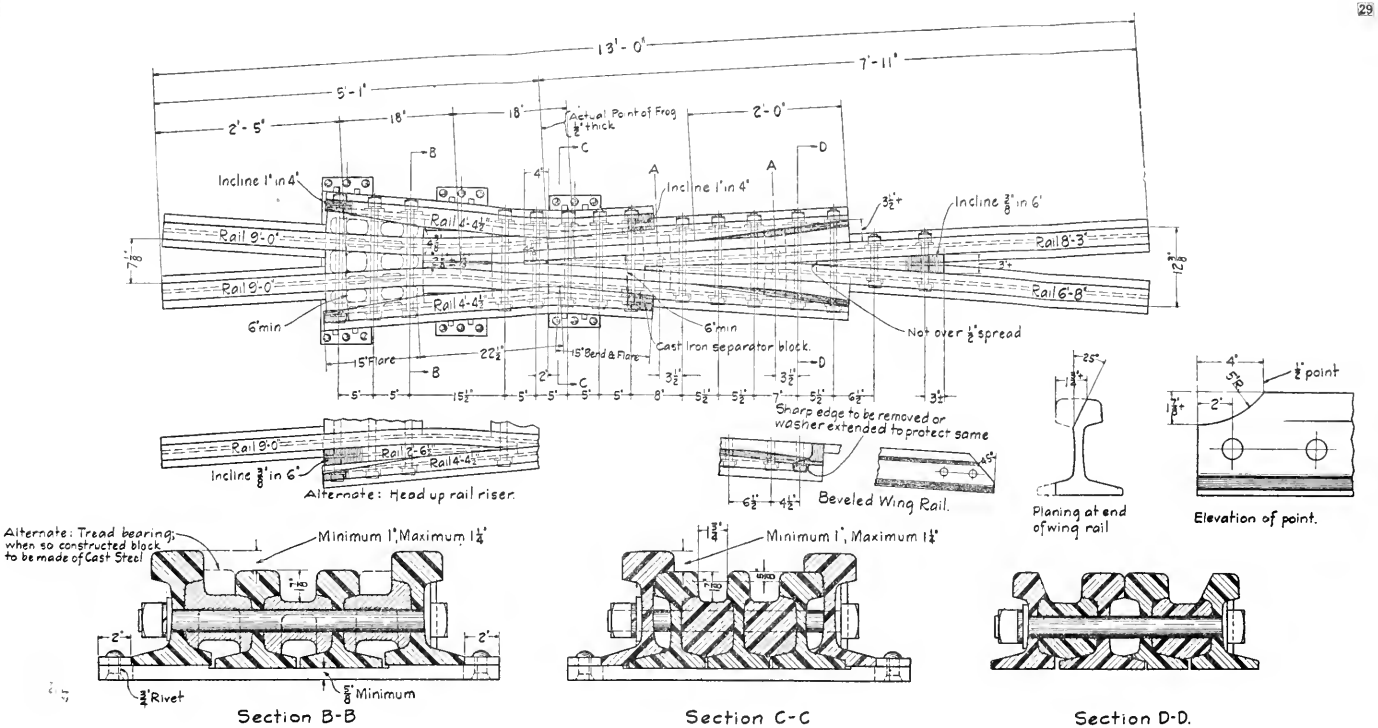


SPECIFICATIONS

Details shown on this plan apply for rails less than 6½" high, and for rails whose combined width of head and base does not exceed 8⅝"

BOLTS—Through bolts 1⅜" dia. for 120 lb. rail and heavier.
1¼" dia. bolts for rails less than 120 lb. and down to rails having 3" fishing height.
1⅛" dia. bolts for rails having less than 3" fishing height, down to and including 80 lb. rail.
Fishing height shall be measured on vertical center line of rail.
All through bolts, including those in heel riser block, to be heat treated steel.
See Specifications, Appendix B.
All through bolts to have extra thick nuts and tight fit except thru castings.
Through bolts to have square heads and nuts with U. S. Standard thread fitted with head locks, nut locks, and bevel washers where necessary to afford square bearing.
Suitable washers in any case shall be placed under nuts to bring same out from under head of rail, so that they may be tightened with standard wrench.

FILLERS—Filler blocks shall fit the fishing angles and the web of rail for a distance of ½" from above and below the base and head respectively and shall maintain the required flangeway.
Throat filler block, point separator blocks and taper and elevation blocks shall be of good quality cast iron.
Body filler blocks shall be of rolled steel in one continuous length, either single or double groove section, or of good quality grey cast iron when specified, in which case they shall be furnished of single groove section and in three lengths with open spaces A as indicated by dotted lines.

HEEL RISER—Heel riser shall be of steel rail, head up with flange upset to properly fit over and rest upon bases of adjoining rails or of other approved design that will insure a proper bearing on the bases of the heel rails and will provide rolled or forged steel wearing surface equal in hardness to rail steel.

RIVETS—Rivets through point rails shall be ¼" less in diameter than the through bolts. They may be countersunk.
If either button or cone head rivets are used, filler blocks must be cut out to clear.

PLATES—When additional bearing plates are required they shall be as per plan No. 305

LENGTHS—Lengths of frogs overall shall not vary more than ½" from length specified. Frogs may be furnished to modified lengths to meet alignment of track or local conditions when specified.

FOOT GUARDS—Additional foot guarding to that shown in plan view to be furnished when so specified.

BEVELED ENDS OF WING RAILS—Flared ends of wing rails may be beveled on an angle of 45° as per detail when so specified.

A. R. E. A.

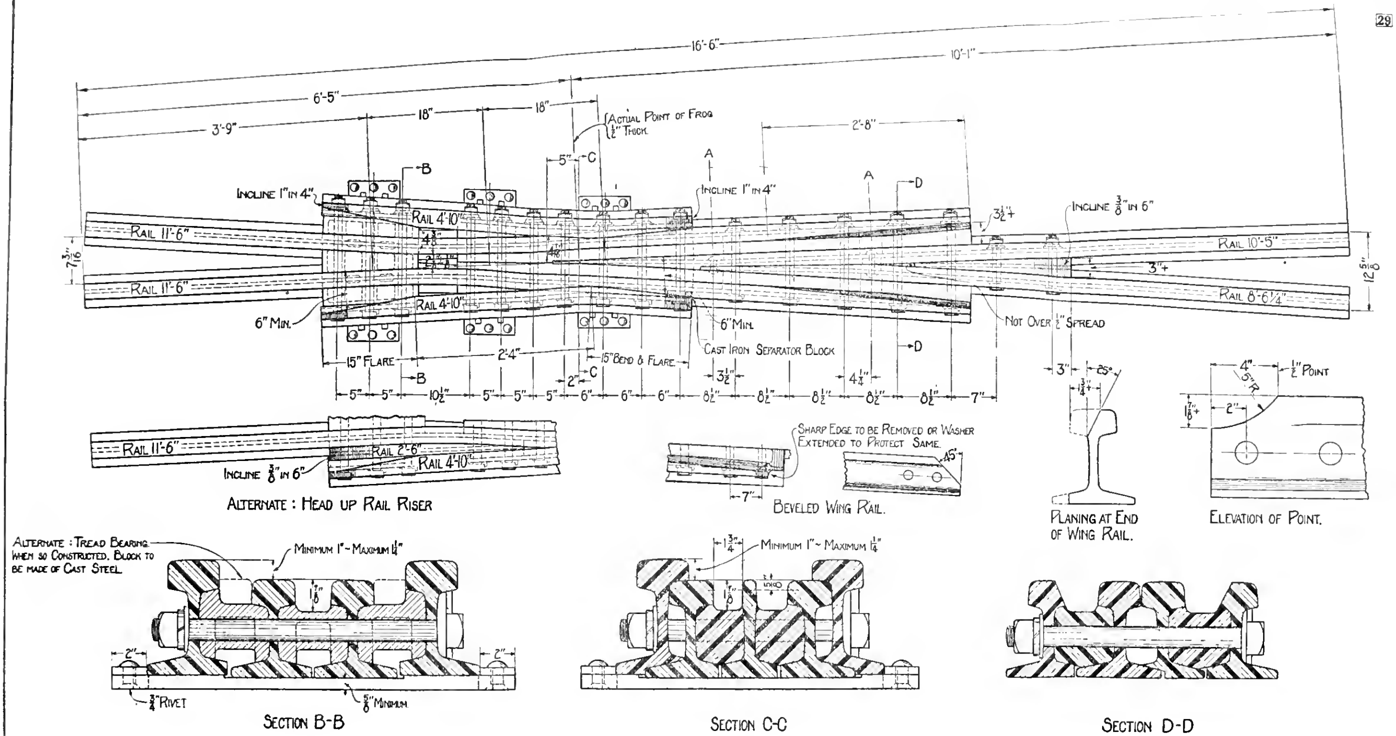
NO.8 SELF GUARDED FROG
BOLTED RIGID TYPE

ANGLE 7°09'10"

NOVEMBER, 1927
REVISED NOVEMBER, 1928

PLAN NO. 343

29



SPECIFICATIONS

Details shown on this plan apply for rails less than 6½" high, and for rails whose combined width of head and base does not exceed 8⅝"

BOLTS—Through bolts 1⅜" dia. for 120 lb. rail and heavier.
1¼" dia. bolts for rails less than 120 lb. and down to rails having 3" fishing height.
1⅛" dia. bolts for rails having less than 3" fishing height, down to and including 80 lb. rail.
Fishing height shall be measured on vertical center line of rail.
All through bolts, including those in heel riser block, to be heat treated steel.
See Specifications, Appendix B.
All through bolts to have extra thick nuts and tight fit except thru castings.
Through bolts to have square heads and nuts with U. S. Standard thread fitted with head locks, nut locks, and bevel washers where necessary to afford square bearing.
Suitable washers in any case shall be placed under nuts to bring same out from under head of rail, so that they may be tightened with standard wrench.

FILLERS—Filler blocks shall fit the fishing angles and the web of rail for a distance of ½" from above and below the base and head respectively and shall maintain the required flangeway.
Throat filler block, point separator blocks and taper and elevation blocks shall be of good quality cast iron.
Body filler blocks shall be of rolled steel in one continuous length, either single or double groove section, or of good quality grey cast iron when specified, in which case they shall be furnished of single groove section and in three lengths with open spaces A as indicated by dotted lines.

HEEL RISER—Heel riser shall be of steel rail, head up with flange upset to properly fit over and rest upon bases of adjoining rails or of other approved design that will insure a proper bearing on the bases of the heel rails and will provide rolled or forged steel wearing surface equal in hardness to rail steel.

RIVETS—Rivets through point rails shall be ¼" less in diameter than the through bolts. They may be countersunk.
If either button or cone head rivets are used, filler blocks must be cut out to clear.

PLATES—When additional bearing plates are required they shall be as per plan No. 305

LENGTHS—Lengths of frogs overall shall not vary more than ½" from length specified. Frogs may be furnished to modified lengths to meet alignment of track or local conditions when specified.

FOOT GUARDS—Additional foot guarding to that shown in plan view to be furnished when so specified.

BEVELED ENDS OF WING RAILS—Flared ends of wing rails may be beveled on an angle of 45° as per detail when so specified.

A. R. E. A.
NO.10 SELF GUARDED FROG
BOLTED RIGID TYPE

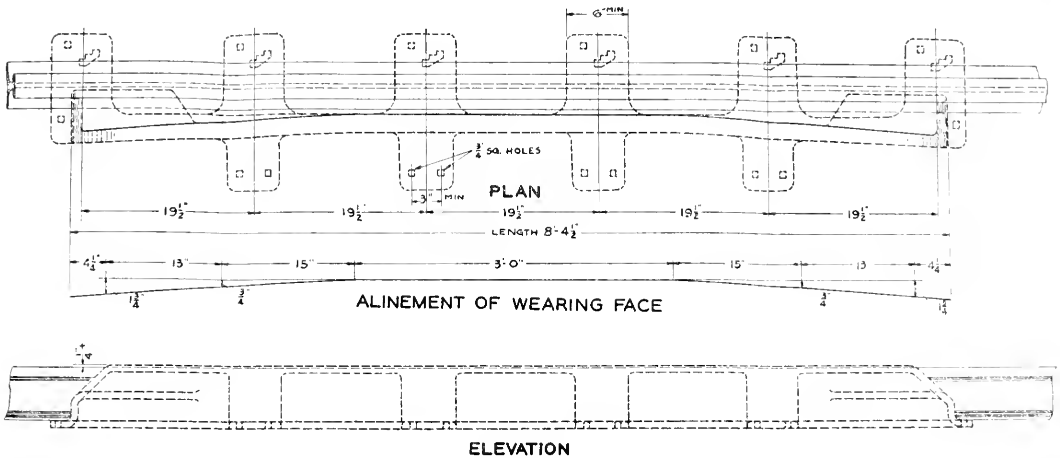
ANGLE 5°43'29"

NOVEMBER 1928

PLAN No. 344

NOTE

BROKEN LINES ARE NOT INTENDED TO INDICATE DESIGN OF BRACES AND BODY OF GUARD RAIL, AS SAME ARE SUBJECT TO VARIATION.



SPECIFICATIONS

WEARING FACE

The alinement shall be straight for 3′ 0″ in center of guard rail and the flare one ach end shall be preferably a double bend, consisting of two straight portions, in order to give the smallest practicable angle of contact for the wheel flange. The wearing face shall have a minimum depth of 7⁄8″ throughout. The radius at top of wearing face shall be approximately 1⁄4″.

HEIGHT

Guard rails approximately 1⁄4″ higher than running rail are recommended where conditions will permit, but height should be not more than 1″ above top of running rail.

PLATES

The tie plates shall be integral with the guard rail, have a minimum width of 6″ (7 1⁄2″ width recommended), a minimum thickness of 11⁄16″ and shall be spaced on 19 1⁄2″ centers. Each plate shall have two spike holes outside of rail. One hole shall be 3⁄4″ square, located so spike head will clear base of rail, and the other hole shall be staggered to provide three or more positions for spiking, so as to allow leeway for gaging guard rail with frog, re-spiking when worn, and use with two or more sections of rail if desired

BRACES

Braces shall be integral with guard rail, located for the four intermediate ties, shall be of sufficient length, have ample bearing on ties, and be adequately designed to prevent overturning of guard rail. Each brace shall have two spike holes or spike notches 3⁄4″ square spaced not less than 3″ centers. The principal member of braces shal have a minimum thickness of 1⁄2″.

WALLS

The walls shall have a minimum thickness of 1⁄2″.

REINFORCING

The guard rail shall be suitably reinforced so as to effectually resist bending between the braces.

FOOT GUARDS

Foot guards cast integral with guard rail are recommended, but separate foot guards of approved design, attached to guard rail or running rail, may be used

ALTERNATES

WEARING FACE

Curved flares of approved alinement may be used.

LENGTH AND PLATE SPACING

Tie Plates may be spaced 19″ minimum or 20″ maximum centers, modifying the length to 8′ 2″ minimum or 8′ 7″ maximum.

A. R. E. A.

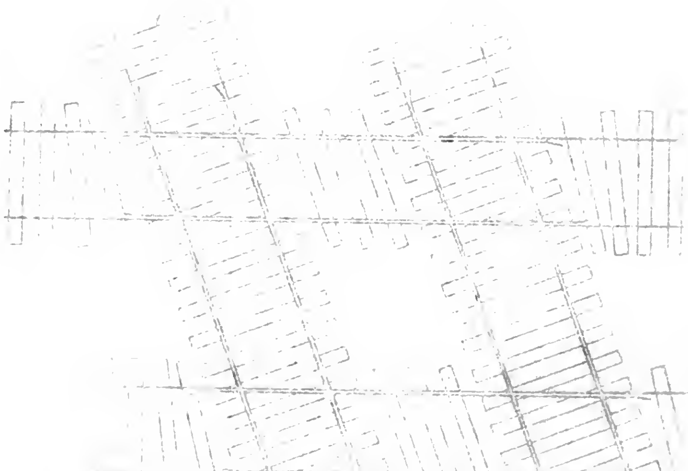
MANGANESE STEEL

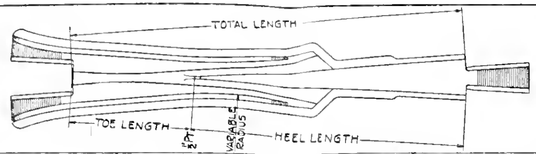
ONE PIECE GUARD RAIL

LENGTH 8′-4 1⁄2″ FOR INSTALLATION ON SIX TIES

NOVEMBER, 1928

PLAN NO. 510





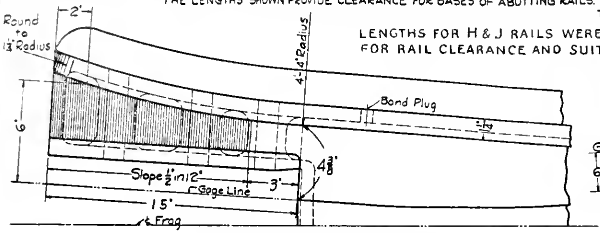
NUMBER OF FROG	CLASS H HEEL LENGTH	CLASS H TOE LENGTH	CLASS H TOTAL LENGTH	CLASS H VARIABLE RADIUS	CLASS J HEEL LENGTH	CLASS J TOE LENGTH	CLASS J TOTAL LENGTH	CLASS J VARIABLE RADIUS	CLASS A HEEL LENGTH	CLASS A TOE LENGTH	CLASS A TOTAL LENGTH	CLASS A VARIABLE RADIUS	CLASS B HEEL LENGTH	CLASS B TOE LENGTH	CLASS B TOTAL LENGTH	CLASS B VARIABLE RADIUS	CLASS C HEEL LENGTH	CLASS C TOE LENGTH	CLASS C TOTAL LENGTH	CLASS C VARIABLE RADIUS	CLASS D HEEL LENGTH	CLASS D TOE LENGTH	CLASS D TOTAL LENGTH	CLASS D VARIABLE RADIUS	NUMBER OF FROG
4	3'-7"	2'-1"	5'-8"	1'-11"	3'-7"	2'-1"	5'-8"	1'-11"	3'-6"	1'-3"	4'-9"	1'-11"	3'-6"	1'-3"	4'-9"	1'-11"	3'-6"	1'-3"	4'-9"	1'-11"	3'-6"	1'-3"	4'-9"	1'-11"	4
5	4'-4"	2'-1"	6'-5"	3'-3"	4'-4"	2'-1"	6'-5"	3'-3"	3'-6"	1'-6"	5'-0"	3'-2"	3'-6"	1'-5"	4'-11"	3'-2"	3'-6"	1'-5"	4'-11"	3'-2"	3'-6"	1'-5"	4'-11"	3'-2"	5
6	5'-2"	2'-3"	7'-5"	4'-11"	4'-5"	2'-1"	6'-6"	4'-10"	4'-1"	1'-10"	5'-11"	4'-10"	3'-11"	1'-9"	5'-8"	4'-10"	3'-9"	1'-8"	5'-5"	4'-9"	3'-7"	1'-8"	5'-3"	4'-9"	6
7	5'-6"	2'-11"	8'-5"	7'-0"	5'-6"	2'-11"	8'-5"	7'-0"	4'-9"	2'-1"	6'-10"	6'-9"	4'-7"	2'-0"	6'-7"	6'-8"	4'-4"	1'-11"	6'-3"	6'-8"	4'-2"	1'-10"	6'-0"	6'-6"	7
8	6'-8"	2'-11"	9'-7"	9'-2"	5'-11"	2'-11"	8'-10"	9'-2"	5'-5"	2'-5"	7'-10"	8'-11"	5'-3"	2'-4"	7'-7"	8'-10"	5'-0"	2'-3"	7'-3"	8'-9"	4'-10"	2'-1"	6'-11"	8'-7"	8
9	7'-4"	3'-9"	11'-1"	12'-0"	6'-7"	3'-9"	10'-4"	12'-0"	6'-1"	2'-9"	8'-10"	11'-5"	5'-10"	2'-7"	8'-5"	11'-3"	5'-7"	2'-6"	8'-1"	11'-2"	5'-5"	2'-4"	7'-9"	11'-0"	9
10	8'-1"	3'-9"	11'-10"	14'-8"	7'-4"	3'-9"	11'-1"	14'-8"	6'-9"	3'-0"	9'-9"	14'-2"	6'-6"	2'-10"	9'-4"	14'-0"	6'-2"	2'-9"	8'-11"	13'-11"	6'-0"	2'-7"	8'-7"	13'-8"	10

CLASSIFICATION OF RAILS [29]

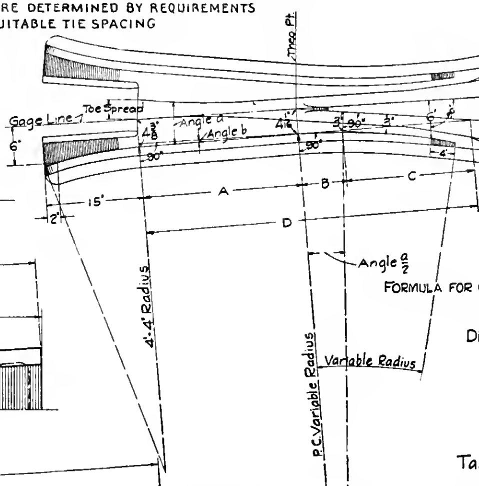
NUMBER OF FROG	H	J	A	B	C	D
	BASE $6\frac{3}{8}$" DOWN TO BUT NOT INCLUDING $6\frac{1}{4}$" HEAD $3\frac{1}{16}$" TO $2\frac{7}{8}$" INCL. OR HEAD AT OR EXCEEDING $3\frac{1}{16}$" WHEN HEAD + BASE DOES NOT EXCEED $9\frac{13}{16}$".	BASE $6\frac{1}{4}$" DOWN TO BUT NOT INCLUDING $5\frac{3}{4}$" HEAD $2\frac{15}{16}$" TO $2\frac{3}{4}$" INCL. OR HEAD AT OR EXCEEDING $2\frac{15}{16}$" WHEN HEAD + BASE DOES NOT EXCEED $9\frac{3}{16}$".	BASE $5\frac{3}{4}$" DOWN TO BUT NOT INCLUDING $5\frac{1}{2}$" HEAD $2\frac{7}{8}$" TO $2\frac{5}{8}$" INCL. OR HEAD AT OR EXCEEDING $2\frac{7}{8}$" WHEN HEAD + BASE DOES NOT EXCEED $8\frac{5}{8}$".	BASE $5\frac{1}{2}$" DOWN TO BUT NOT INCLUDING $5\frac{1}{4}$" HEAD $2\frac{5}{8}$" TO $2\frac{9}{16}$" INCL. OR HEAD AT OR EXCEEDING $2\frac{9}{16}$" WHEN HEAD + BASE DOES NOT EXCEED $8\frac{1}{16}$".	BASE $5\frac{1}{4}$" DOWN TO BUT NOT INCLUDING 5" HEAD $2\frac{11}{16}$" TO $2\frac{7}{16}$" INCL. OR HEAD AT OR EXCEEDING $2\frac{11}{16}$" WHEN HEAD + BASE DOES NOT EXCEED $7\frac{15}{16}$".	BASE 5" DOWN TO BUT NOT INCLUDING $4\frac{1}{2}$" HEAD $2\frac{1}{16}$" TO $2\frac{7}{16}$" INCL. OR HEAD AT OR EXCEEDING $2\frac{1}{2}$" WHEN HEAD + BASE DOES NOT EXCEED $7\frac{11}{16}$".
4	150 R.E.	127 DUD.	95 B.&A.	90 A.S.C.E.	85 A.S.C.E.	80 A.S.C.E.
5		130 R.E.	100 A.S.C.E.	90 N.H.	85 C.B.&Q.	80 A.R.A-A
6		140 R.E.	100 I.R.T.	90 U.P.	85 MO.PAC.	80 CAM. 54
7			100 DUD.	91 D.L.&W.	85 D.&R.G.	80 CAN. NOR
8			105 DUD.	100 A.R.A.-A.	90 A.R.A.-A.	80 H.V.
9			110 L.V.	100 P.&R.	90 AT.&S.F.	80 DUD.
10			115 DUD.	100 P.R.R.	90 C.&N.W.	85 CAN PAC
			120 R.E.	100 N.H.	90 D.&R.G.	85 D.&R.G.-Ca
			130 P.S.	100 R.E.	90 I.R.T.	85 GR. NOR
				101 D.L.&W.	90 P.&R.	85 K.C.SO.
				105 D.L.&W.	100 A.R.A-B.	85 DUD.
				107 N.H.	100 C.&N.W.	85 N.Y.C.&ST
				110 GR.NOR.		85 P.R.R.
				110 R.E.		85 P.S.
						85 SAL.
						85 SOO LIN
						90 A.R.A-
						90 GR. NOR
						90 DUD.
						100 GR. NOR
						100 I.S.CO
						100 P.S.

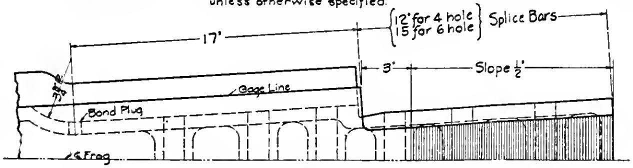
THE LENGTHS SHOWN PROVIDE CLEARANCE FOR BASES OF ABUTTING RAILS. FIGURES BELOW HEAVY LINES WERE DETERMINED BY THIS CLEARANCE REQUIREMENT. THOSE ABOVE HEAVY LINES ARE MINIMUM LENGTHS AND WERE FIXED BY OTHER CONSIDERATIONS.

LENGTHS FOR H & J RAILS WERE DETERMINED BY REQUIREMENTS FOR RAIL CLEARANCE AND SUITABLE TIE SPACING



TYPICAL DETAIL AT TOE END.
Beveled ends optional and may be furnished as per details shown on Plan Nº 643, unless otherwise specified.





TYPICAL DETAIL AT HEEL END.
Beveled ends optional and may be furnished as per details shown on Plan Nº 643, unless otherwise specified.

FORMULA FOR CURVING FLANGE GUARDS BACK OF THEORETICAL POINT

$$\text{Radius} = \frac{B}{\tan\frac{a}{2}}$$

$$\text{Distance "D"} = \frac{\text{Toe Spread} + 4\frac{3}{8}"}{\tan a}$$

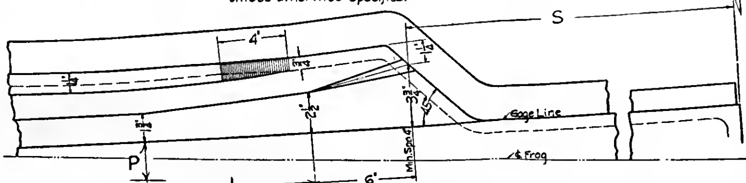
$$\text{" "C"} = \frac{3}{\sin a}$$

" "A" = Distance from theo. pt. to end of t

$$\text{" "B"} = D - (A + C)$$

$$\text{Angle } a = \text{Angle } b + \text{frog angle.}$$

$$\text{Tan. angle } b = \frac{\frac{5}{16}"}{A}$$



DETAIL OF STANDARD FLARE.

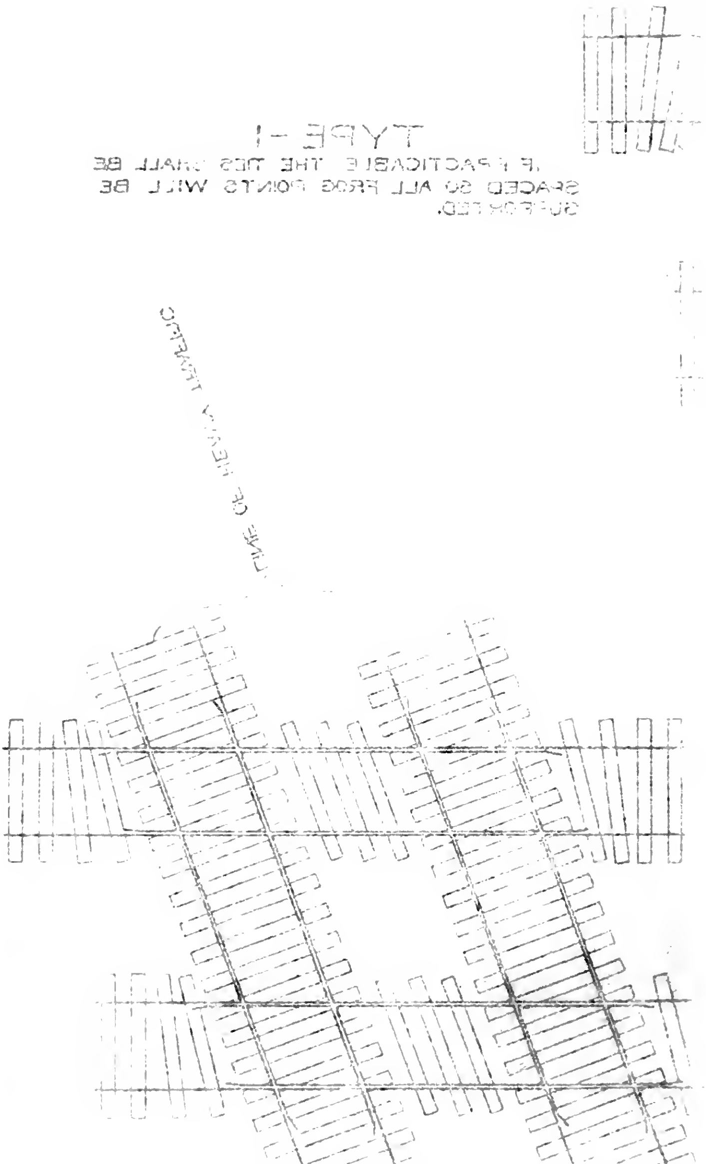
No. OF FROG	CLASS	P	L	S
4	ALL	P FOLLOWS FROM L&S	6"	$23\frac{5}{16}$"
5&6	A-B-C-D		6"	$23\frac{5}{16}$"
7	D		6"	$23\frac{5}{16}$"
5&6	H&J	$2\frac{1}{4}$"	10"	S FOLLOWS FROM L&P
7	ALL EXCEPT-D	$2\frac{1}{4}$"	10"	
8&9	ALL	$2\frac{1}{4}$"	10"	
10	ALL	$2\frac{1}{4}$"	$11\frac{1}{2}$"	

Note: For additional sections and other details not shown hereon see plan Nº 643.

A.R.E.A.
STANDARD DIMENSIONS FOR SELF GUARDED FROGS SOLID MANGANESE STEEL

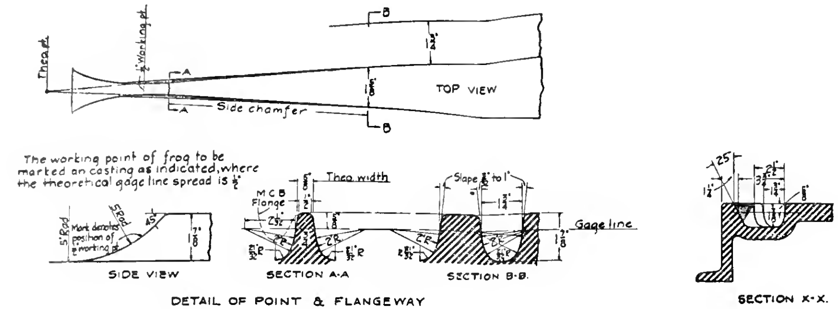
NOVEMBER 1926.
REVISED NOVEMBER 1928

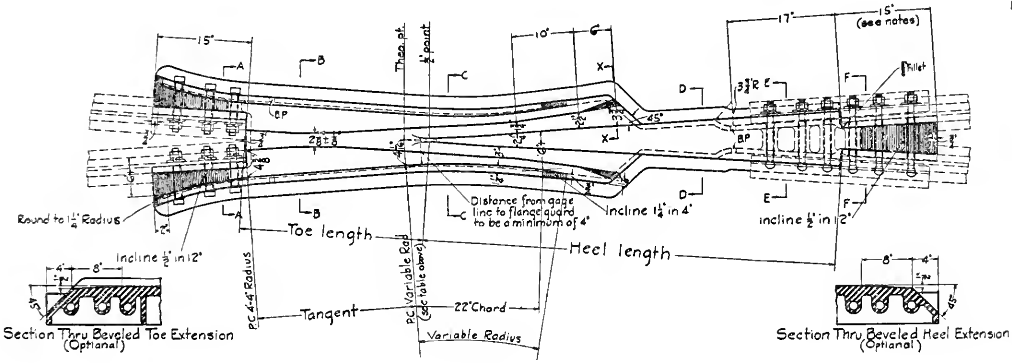
PLAN No. 640


TYPE-I
IF PRACTICABLE THE TIES SHALL BE SPACED SO ALL FROG POINTS WILL BE SUPPORTED.
LINE OF HEAVY TRAFFIC

29

CLASS		HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	VARIABLE RADIUS
H	Rail base 6 3/4" down but not incl. 6 1/4". Rail head 3 1/16" to 2 7/8" incl., or rail head at or exceeding 3 1/16" when head & base do not exceed 9 13/16"	6'-8"	2'-11"	9'-7"	9'-2"
J	Rail base 6 1/4" down but not incl. 5 3/4". Rail head 2 15/16" to 2 3/4" incl., or rail head at or exceeding 2 15/16" when head & base do not exceed 9 7/16".	5'-11"	2'-11"	8'-10"	9'-2"
A	Rail base 5 3/4" down but not incl. 5 1/2". Rail head 2 7/8" to 2 5/8" incl., or rail head at or exceeding 2 7/8" when head & base do not exceed 8 5/8"	5'-5"	2'-5"	7'-10"	8'-11"
B	Rail base 5 1/2" down but not incl. 5 1/4". Rail head 2 13/16" to 2 9/16" incl., or rail head at or exceeding 2 13/16" when head & base do not exceed 8 5/16"	5'-3"	2'-4"	7'-7"	8'-10"
C	Rail base 5 1/4" down but not incl. 5". Rail head 2 11/16" to 2 7/16" incl., or rail head at or exceeding 2 11/16" when head & base do not exceed 7 15/16"	5'-0"	2'-3"	7'-3"	8'-9"
D	Rail base 5" down but not incl. 4 3/4". Rail head 2 11/16" to 2 7/16" incl., or rail head at or exceeding 2 11/16" when head & base do not exceed 7 11/16"	4'-10"	2'-1"	6'-11"	8'-7"





NOTES:

All special length splice-bar bolts for connecting adjoining rails to be furnished with frog. Bolts to have square nuts, and nutlocks, unless otherwise specified, or required.

Splice bars not to be furnished with frog unless specified or when special bars are required. Maximum length of splice-bars to be used, 30 inches.

One or more plug inserts of iron or soft steel, to allow for drilling of electrical bond holes to be cast in vertical walls, as indicated by B.P. on drawing, when so specified.

Bolt holes thro casting to be 1/8 inch larger than bolt diameter.

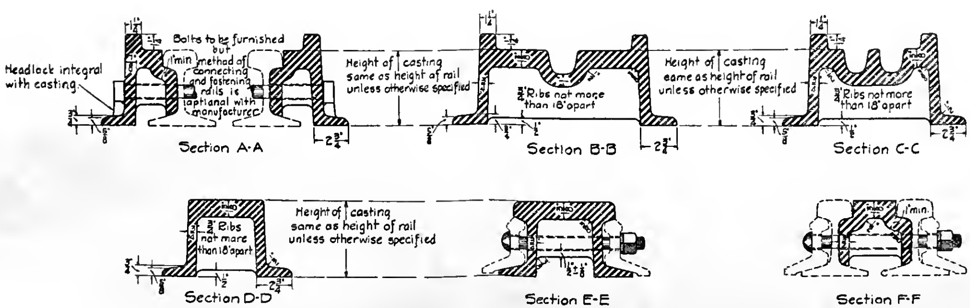
Heel extension only to be made 12 inches long for 4 hole splice bars.

Base flange of manganese casting may be extended at tie locations, of approved design, for additional tie supports when so specified, or tie plates may be used.

Beveled ends optional and may be furnished as per details, unless otherwise specified.

When so specified 3/4" × 8" tie plates of a medium grade of commercial mild steel shall be furnished with frog to suit tie layout.

For details showing method of laying out Self Guarded Frogs Nos 4 to 10 inclusive see plan No 640.



A.R.E.A.

NO. 8 SELF GUARDED FROG

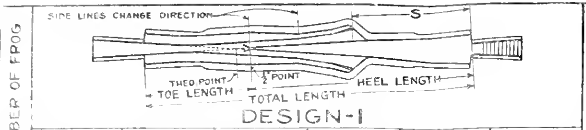
SOLID MANGANESE STEEL

ANGLE 7°09'10"

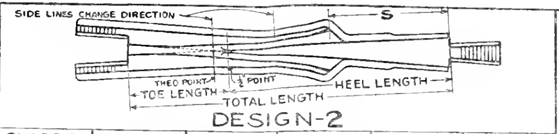
NOVEMBER 1925
REVISED NOVEMBER 1926
REVISED NOVEMBER 1928

PLAN No. 643

TYPE - I
IF PRACTICABLE THE TIES SHALL BE SPACED SO ALL FROG POINTS WILL BE SUPPORTED.
LINE OF HEAVY TRAFFIC



DESIGN-1



DESIGN-2

NUMBER OF FROG	DESIGN-1 CLASS-H			CLASS-J			CLASS-A			CLASS-B			CLASS-C			CLASS-D			NUMBER OF FROG
	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	
4	3'-7"	2'-1"	5'-8"	3'-7"	2'-1"	5'-8"	3'-6"	22"	5'-4"	3'-6"	22"	5'-4"	3'-6"	22"	5'-4"	3'-6"	22"	5'-4"	4
5	4'-4"	2'-1"	6'-5"	4'-4"	2'-1"	6'-5"	3'-6"	2'-0"	5'-6"	3'-6"	2'-0"	5'-6"	3'-6"	2'-0"	5'-6"	3'-6"	2'-0"	5'-6"	5
6	5'-2"	2'-3"	7'-5"	4'-5"	2'-3"	6'-8"	4'-1"	2'-3"	6'-4"	3'-11"	2'-3"	6'-2"	3'-9"	2'-3"	6'-0"	3'-7"	2'-3"	5'-10"	6
7	5'-6"	2'-11"	8'-5"	5'-6"	2'-11"	8'-5"	4'-9"	2'-5"	7'-2"	4'-7"	2'-5"	7'-0"	4'-4"	2'-5"	6'-9"	4'-2"	2'-5"	6'-7"	7
8	6'-8"	2'-11"	9'-7"	5'-11"	2'-11"	8'-10"	5'-5"	2'-7"	8'-0"	5'-3"	2'-7"	7'-10"	5'-0"	2'-7"	7'-7"	4'-10"	2'-7"	7'-5"	8
9	7'-4"	3'-9"	11'-1"	6'-7"	3'-9"	10'-4"	6'-1"	2'-9"	8'-10"	5'-10"	2'-9"	8'-7"	5'-7"	2'-9"	8'-4"	5'-5"	2'-9"	8'-2"	9
10	8'-1"	3'-9"	11'-10"	7'-4"	3'-9"	11'-1"	6'-9"	3'-0"	9'-9"	6'-6"	3'-0"	9'-6"	6'-2"	3'-0"	9'-2"	6'-0"	3'-0"	9'-0"	10
11	8'-10"	4'-6"	13'-4"	8'-1"	3'-9"	11'-10"	7'-5"	3'-4"	10'-9"	7'-2"	3'-2"	10'-4"	6'-10"	3'-2"	10'-0"	6'-7"	3'-2"	9'-9"	11
12	9'-7"	4'-6"	14'-1"	8'-10"	4'-6"	13'-4"	8'-2"	3'-8"	11'-10"	7'-10"	3'-5"	11'-3"	7'-5"	3'-4"	10'-9"	7'-2"	3'-4"	10'-6"	12

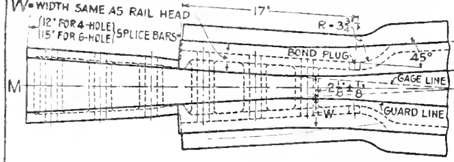
NUMBER OF FROG	DESIGN-2 CLASS-H			CLASS-J			CLASS-A			CLASS-B			CLASS-C			CLASS-D			NUMBER OF FROG
	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	HEEL LENGTH	TOE LENGTH	TOTAL LENGTH	
4	3'-7"	2'-1"	5'-8"	3'-7"	2'-1"	5'-8"	3'-6"	15"	4'-9"	3'-6"	15"	4'-9"	3'-6"	15"	4'-9"	3'-6"	15"	4'-9"	4
5	4'-4"	2'-1"	6'-5"	4'-4"	2'-1"	6'-5"	3'-6"	18"	5'-0"	3'-6"	17"	4'-11"	3'-6"	17"	4'-11"	3'-6"	17"	4'-11"	5
6	5'-2"	2'-3"	7'-5"	4'-5"	2'-1"	6'-6"	4'-1"	22"	5'-11"	3'-11"	21"	5'-8"	3'-9"	20"	5'-5"	3'-7"	20"	5'-3"	6
7	5'-6"	2'-11"	8'-5"	5'-6"	2'-11"	8'-5"	4'-9"	2'-1"	6'-10"	4'-7"	2'-0"	6'-7"	4'-4"	23"	6'-3"	4'-2"	22"	6'-0"	7
8	6'-8"	2'-11"	9'-7"	5'-11"	2'-11"	8'-10"	5'-5"	2'-5"	7'-10"	5'-3"	2'-4"	7'-7"	5'-0"	2'-3"	7'-3"	4'-10"	2'-1"	6'-11"	8
9	7'-4"	3'-9"	11'-1"	6'-7"	3'-9"	10'-4"	6'-1"	2'-9"	8'-10"	5'-10"	2'-7"	8'-5"	5'-7"	2'-6"	8'-1"	5'-5"	2'-4"	7'-9"	9
10	8'-1"	3'-9"	11'-10"	7'-4"	3'-9"	11'-1"	6'-9"	3'-0"	9'-9"	6'-6"	2'-10"	9'-4"	6'-2"	2'-9"	8'-11"	6'-0"	2'-7"	8'-7"	10
11	8'-10"	4'-6"	13'-4"	8'-1"	3'-9"	11'-10"	7'-5"	3'-4"	10'-9"	7'-2"	3'-2"	10'-4"	6'-10"	3'-0"	9'-10"	6'-7"	2'-10"	9'-5"	11
12	9'-7"	4'-6"	14'-1"	8'-10"	4'-6"	13'-4"	8'-2"	3'-8"	11'-10"	7'-10"	3'-5"	11'-3"	7'-5"	3'-4"	10'-9"	7'-2"	3'-1"	10'-3"	12

THE LENGTHS SHOWN PROVIDE CLEARANCE FOR BASES OF ABUTTING RAILS. FIGURES BELOW HEAVY LINES WERE DETERMINED BY THIS CLEARANCE REQUIREMENT; THOSE ABOVE HEAVY LINES ARE MINIMUM LENGTHS AND WERE FIXED BY OTHER CONSIDERATIONS.

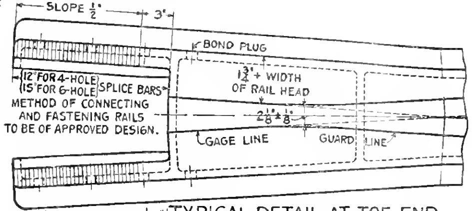
LENGTHS FOR H AND J RAILS WERE DETERMINED BY REQUIREMENTS FOR RAIL CLEARANCE AND SUITABLE TIE SPACING

CLASSIFICATION OF RAILS [29]

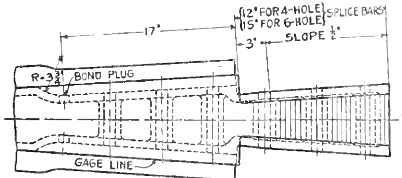
NUMBER OF FROG	H	J	A	B	C	D
	BASE $6\frac{3}{4}$" DOWN TO BUT NOT INCLUDING $6\frac{1}{4}$" HEAD $3\frac{1}{16}$" TO $2\frac{7}{8}$" INCL OR HEAD AT OR EXCEEDING $3\frac{1}{16}$" WHEN HEAD + BASE DOES NOT EXCEED $9\frac{13}{16}$"	BASE $6\frac{1}{4}$" DOWN TO BUT NOT INCLUDING $5\frac{3}{4}$" HEAD $2\frac{15}{16}$" TO $2\frac{3}{4}$" INCL OR HEAD AT OR EXCEEDING $2\frac{15}{16}$" WHEN HEAD + BASE DOES NOT EXCEED $9\frac{3}{16}$"	BASE $5\frac{3}{4}$" DOWN TO BUT NOT INCLUDING $5\frac{1}{2}$" HEAD $2\frac{7}{8}$" TO $2\frac{5}{8}$" INCL. OR HEAD AT OR EXCEEDING $2\frac{7}{8}$" WHEN HEAD + BASE DOES NOT EXCEED $8\frac{5}{8}$"	BASE $5\frac{1}{2}$" DOWN TO BUT NOT INCLUDING $5\frac{1}{4}$" HEAD $2\frac{13}{16}$" TO $2\frac{9}{16}$" INCL. OR HEAD AT OR EXCEEDING $2\frac{13}{16}$" WHEN HEAD + BASE DOES NOT EXCEED $8\frac{5}{16}$"	BASE $5\frac{1}{4}$" DOWN TO BUT NOT INCLUDING 5" HEAD $2\frac{11}{16}$" TO $2\frac{7}{16}$" INCL. OR HEAD AT OR EXCEEDING $2\frac{11}{16}$" WHEN HEAD + BASE DOES NOT EXCEED $7\frac{15}{16}$"	BASE 5" DOWN TO BUT NOT INCLUDING $4\frac{1}{2}$" HEAD $2\frac{11}{16}$" TO $2\frac{7}{16}$" INCL. OR HEAD AT OR EXCEEDING $2\frac{11}{16}$" WHEN HEAD + BASE DOES NOT EXCEED $7\frac{11}{16}$"
4	150 R.E.	127 DUD.	95 B.&A.	90 A.S.C.E.	85 A.S.C.E.	80 A.S.C.E
5		130 R.E	100 A.S.C.E.	90 N.H.	85 C.B.&Q.	80 A.R.A.A
6		140 R.E	100 I.R.T.	90 U.P.	85 MO.PAC.	80 CAM.540
7			100 DUD.	91 D.L.&W.	85 D.&R.G	80 CAN.NOR
8			105 DUD.	100 A.R.A-A.	90 A.R.A-A	80 H.V.
9			110 L.V.	100 P.&R.	90 A.T.&S.F.	80 DUD.
10			115 DUD.	100 P.R.R.	90 C.&N.W.	85 CAN.PAC
11			120 R.E.	100 N.H.	90 D.&R.G.	85 D.&R.G.C.&S.
12			130 P.S.	100 R.E.	90 I.R.T.	85 GR.NOR.
				101 D.L.&W.	90 P.&R.	85 K.C.S.O.
				105 D.L.&W.	100 A.R.A-B.	85 DUD.
				107 N.H.	100 C.&N.W.	85 N.Y.C.&ST.L.
				110 GR.NOR.		85 P.R.R.
				110 R.E.		85 P.S.
						85 S.A.L.
						85 SOO LINE
						90 A.R.A-B
						90 GR.NOR.
						90 DUD.
						100 GR.NOR.
						100 I.S.CO.
						100 P.S.



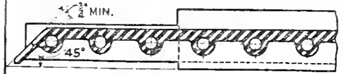
TYPICAL DETAIL AT TOE END-DESIGN I



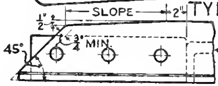
TYPICAL DETAIL AT TOE END DESIGN 2



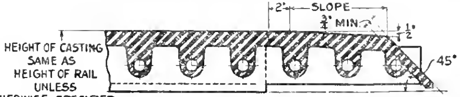
TYPICAL DETAIL AT HEEL END-DESIGNS I & 2



SEC. M-M WHEN END IS BEVELED

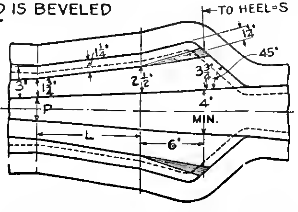


SIDE VIEW OF END WHEN BEVELED (SEE NOTES)

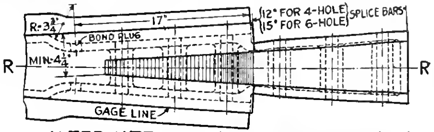


SEC. N-N WHEN END IS BEVELED (SEE NOTES)

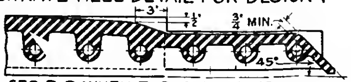
No OF FROG	RAILS	P	L	S
4	ALL	P FOLLOWS FROM L & S	6"	$23\frac{5}{16}$"
5 & 6	A-B-C-D		6"	$23\frac{5}{16}$"
7	D		6"	$23\frac{5}{16}$"
5 & 6	H & J	$2\frac{1}{4}$"	10"	S FOLLOWS FROM L & P
7	ALL EXCEPT D	$2\frac{1}{4}$"	10"	
8 & 9	ALL	$2\frac{1}{4}$"	10"	
10	ALL	$2\frac{1}{4}$"	$11\frac{1}{2}$"	
11	ALL	$2\frac{1}{4}$"	$13\frac{1}{4}$"	
12	ALL	$2\frac{1}{4}$"	15"	



DETAIL OF STANDARD FLARE



ALTERNATE HEEL DETAIL FOR DESIGN I



SEC. R-R WHEN END IS BEVELED (SEE NOTES)

NOTES:

All special length splice bar bolts for connecting adjoining rails to be furnished with frog. Bolts to have button heads, oval necks, square nuts and spring washers unless otherwise specified or required.

Splice bars not to be furnished with frog unless specified or when special bars are required. Maximum length of splice bars to be used, 30".

One or more plug inserts, of iron or soft steel, to permit of drilling electrical bond holes, to be cast in vertical walls, as indicated on drawing, when so specified.

Bolt holes through casting to be ¼" larger than bolt diameter

The 45° bevel ends shown are optional; may be furnished unless otherwise specified. (Beveled ends may require extensions somewhat longer than 12" and for 4-hole and 6-hole splice bars respectively.)

Tie plates should be used.

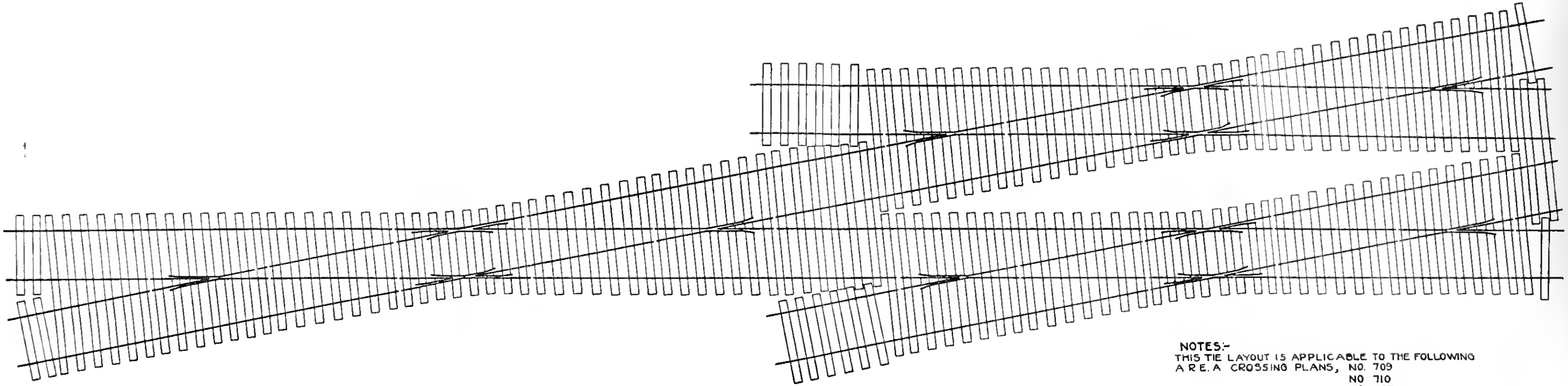
When so specified ¾" x 8" tie plates of a medium grade of commercial mild steel, shall be furnished with frog, to suit tie layout; see plans 271 to 279 inclusive for frogs for H and J rails.

For additional sections and other details not shown hereon, see plans Nos. 651 to 656 inclusive, showing individual frogs.

A. R. E. A.
STANDARD DIMENSIONS FOR
SOLID MANGANESE STEEL FROGS

REDRAWN AND REVISED NOVEMBER 1926
REVISED NOVEMBER 1926

PLAN No. 670



DRAWN AT 10°-0'

Scale

NOTES:-

THIS TIE LAYOUT IS APPLICABLE TO THE FOLLOWING A.R.E.A. CROSSING PLANS, NO. 709
NO. 710
NO. 767
NO. 768
NO. 775

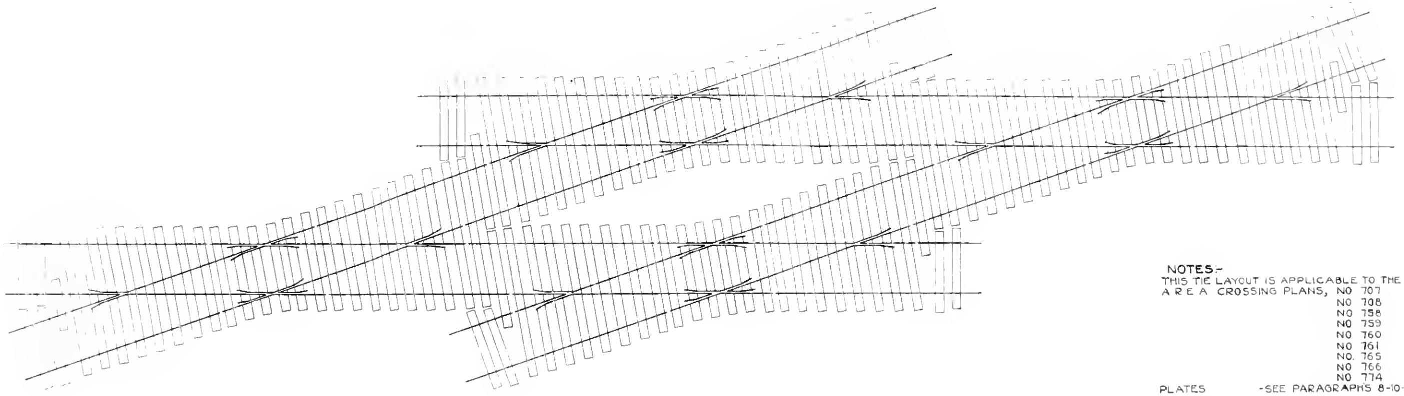
PLATES	-SEE PARAGRAPHS 8-10-11 PLAN 700.
DRAINAGE	-CROSSING INSTALLATION MUST BE SO DRAINED THAT ALL WATER WILL BE DIVERTED AWAY FROM THE ROADBED
BALLAST	-A MINIMUM DEPTH OF 12" OF ROCK, SLAG OR WASHED GRAVEL IS RECOMMENDED BELOW BOTTOM OF TIE.
CROSSING TIES	-CROSSING TIES MUST BE KEPT TAMPED TO PROVIDE FULL BEARING; SPACED ABOUT 20" C. TO C.

A. R. E. A.

TIE LAYOUT FOR RAILROAD CROSSINGS

ANGLES 8° 10′ TO 14° 15′

NOVEMBER 1928 — PLAN NO. 719-A



DRAWN AT 20° - 0'

Scale

NOTES:-
THIS TIE LAYOUT IS APPLICABLE TO THE FOLLOWING
A R E A CROSSING PLANS, NO 707
NO 708
NO 758
NO 759
NO 760
NO 761
NO. 765
NO 766
NO 774

PLATES -SEE PARAGRAPHS 8-10-11 PLAN 700.

DRAINAGE -CROSSING INSTALLATION MUST BE SO DRAINED THAT ALL WATER WILL BE DIVERTED AWAY FROM THE ROADBED

BALLAST - A MINIMUM DEPTH OF 12" OF ROCK, SLAG OR WASHED GRAVEL IS RECOMMENDED BELOW BOTTOM OF TIE.

CROSSING TIES -CROSSING TIES MUST BE KEPT TAMPED TO PROVIDE FULL BEARING; SPACED ABOUT 20" C TO C

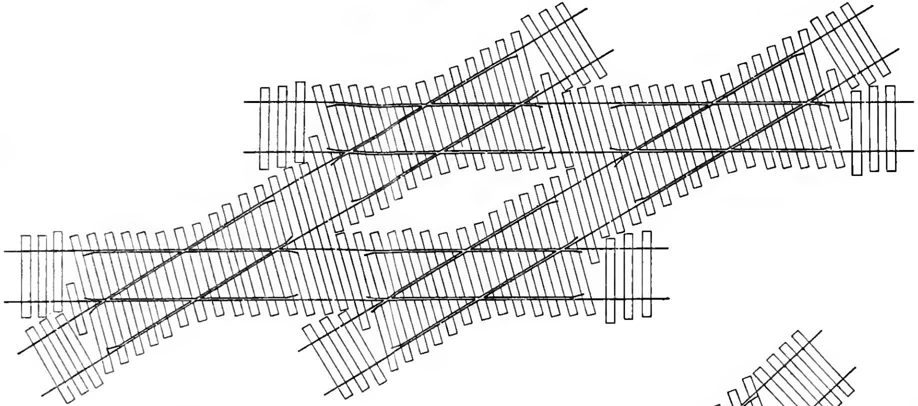
A. R. E. A.

TIE LAYOUT FOR RAILROAD CROSSINGS

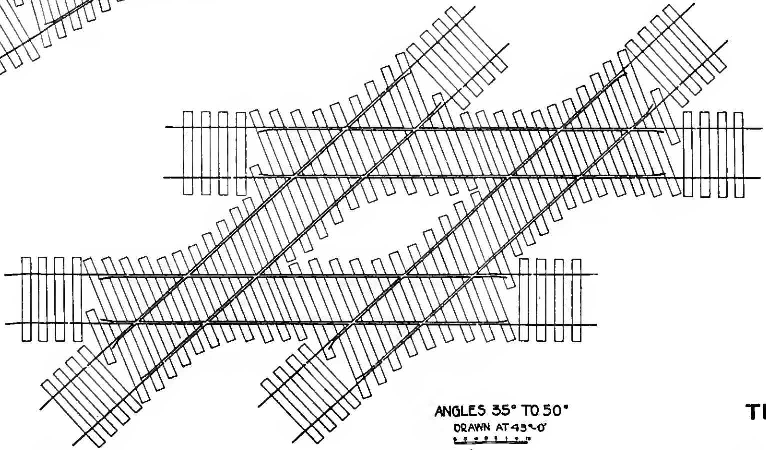
ANGLES 14° 15' TO 25°

NOVEMBER 1928

PLAN NO. 719-B



ANGLES 25° TO 35°
DRAWN AT 30°0'
Scale –



ANGLES 35° TO 50°
DRAWN AT 45°-0'
Scale –

NOTES:–

THESE TIE LAYOUTS ARE APPLICABLE TO THE FOLLOWING A.R.E.A CROSSING PLANS,

ANGLES 25° TO 35°,	ANGLES 35° TO 50°;
PLAN NO. 705	PLAN NO. 703
706	704
756	754
757	755
763	702
764	772
773	773

PLATES – SEE PARAGRAPHS 8-10-11 PLAN 700.

DRAINAGE – CROSSING INSTALLATION MUST BE SO DRAINED THAT ALL WATER WILL BE DIVERTED AWAY FROM THE ROADBED.

BALLAST – A MINIMUM DEPTH OF 12" OF ROCK, SLAG OR WASHED GRAVEL IS RECOMMENDED BELOW BOTTOM OF TIE.

CROSSING TIES – CROSSING TIES MUST BE KEPT TAMPED TO PROVIDE FULL BEARING; SPACED ABOUT 20" C. TO C.

CONCRETE CROSSING FOUNDATION – SEE PLAN NO. 721.

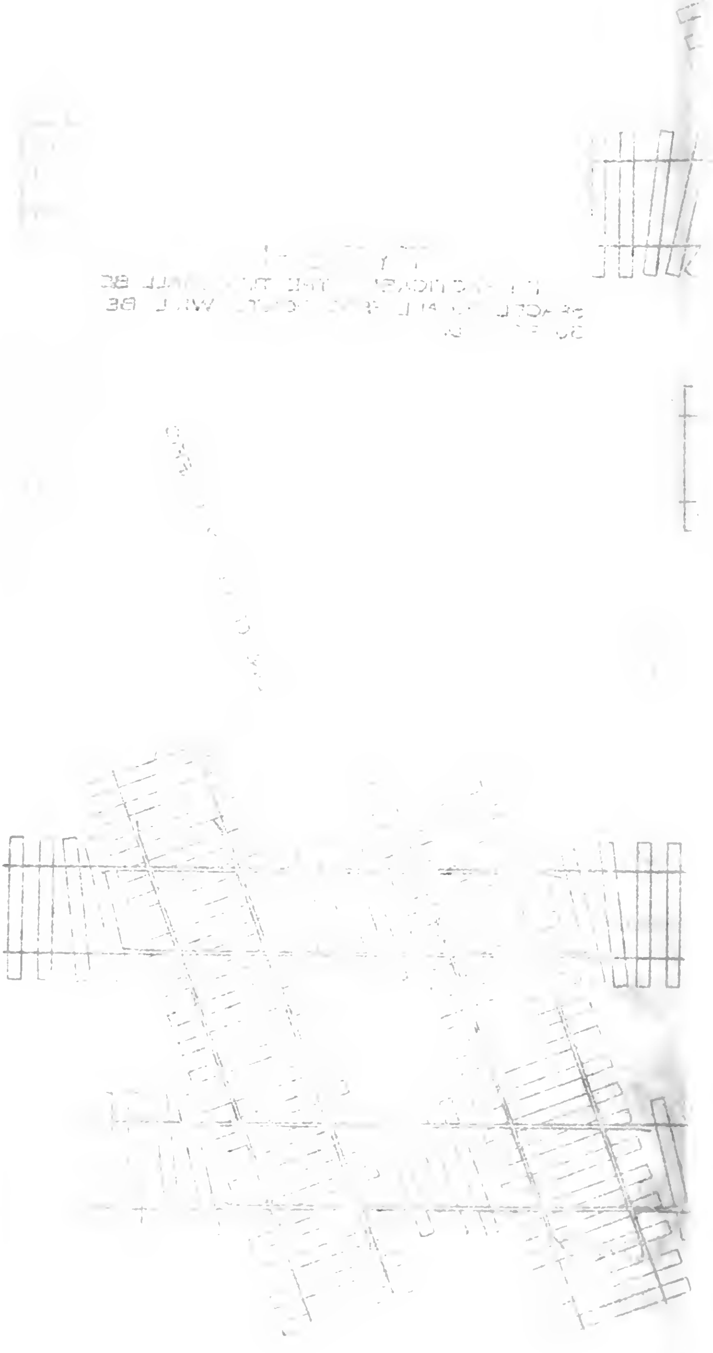
A. R. E. A.

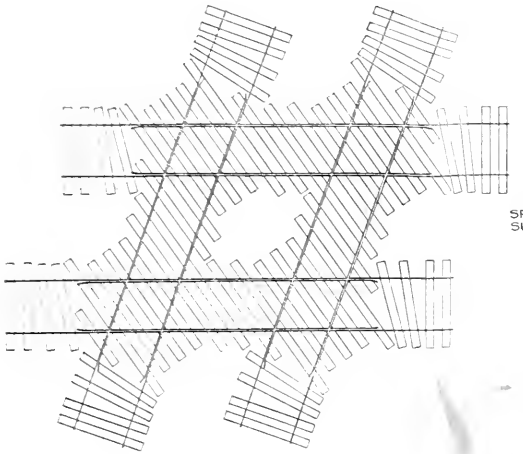
TIE LAYOUT FOR RAILROAD CROSSINGS

ANGLES 25° TO 50°

NOVEMBER 1928

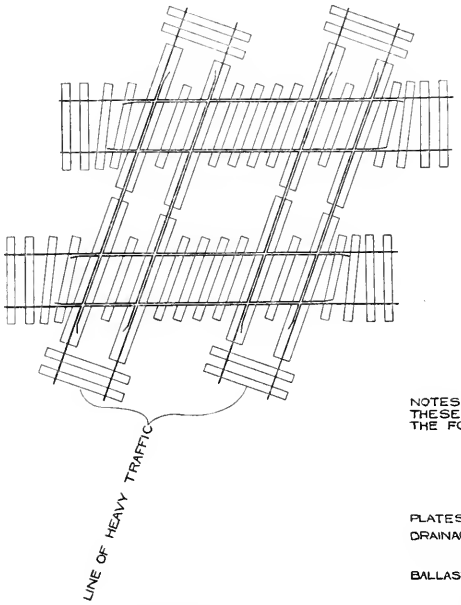
PLAN NO. 719-C





TYPE - 1

IF PRACTICABLE THE TIES SHALL BE SPACED SO ALL FROG POINTS WILL BE SUPPORTED.



DRAWN AT 70°-0'

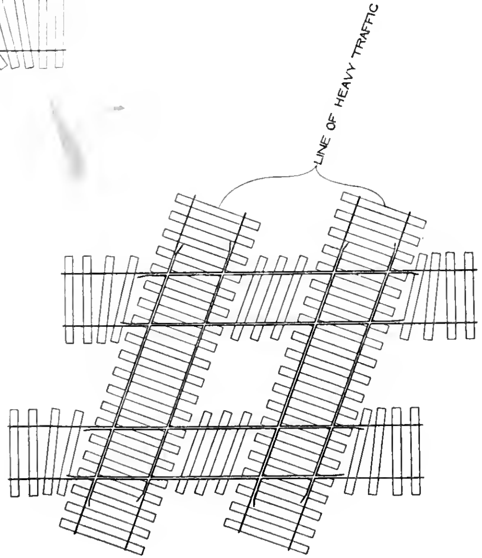
Scale

TYPE - 2

USE TWO HEAVY TIMBERS OR TIES BOLTED TOGETHER WITH MINIMUM WIDTH OF 18" AND LONG ENOUGH TO SUPPORT THE ARMS OF THE CROSSING.

IF DESIRED THE TIMBERS MAY BE FRAMED AND PLACED UNDER THE FOUR SIDES OF EACH CROSSING.

LONG TIMBERS SHOULD BE LONGITUDINAL WITH LINE OF HEAVY TRAFFIC.



TYPE - 3

STANDARD CROSS TIES ONLY ARE REQUIRED.

NOTES:-

THESE TIE LAYOUTS ARE APPLICABLE TO THE FOLLOWING CROSSING PLANS NO. 701, NO. 702, NO. 716, NO. 771, NO. 771-B, NO. 772, NO. 776, NO. 777

PLATES - SEE PARAGRAPHS 8-10-11 PLAN NO 700

DRAINAGE - CROSSING INSTALLATION MUST BE SO DRAINED THAT ALL WATER WILL BE DIVERTED AWAY FROM THE ROADBED.

BALLAST - A MINIMUM DEPTH OF 12" OF ROCK, SLAG OR WASHED GRAVEL IS RECOMMENDED BELOW BOTTOM OF TIE.

CROSSING TIES - CROSSING TIES MUST BE KEPT TAMPED TO PROVIDE FULL BEARING; SPACED ABOUT 20" C. TO C.

CONCRETE CROSSING FOUNDATION - SEE PLAN NO. 721.

A. R. E. A.

TIE LAYOUTS FOR RAILROAD CROSSINGS

ANGLES 50° TO 90°

NOVEMBER 1928

PLAN NO. 719-D

(C) Hand Oiling, where all of laborer's time is charged to oiling, no other duties assigned. (Labor rate 38 cents per hour.)
(D) Mechanical Oiling (by machine).

The Committee feels that this subject is a familiar one to many engineers but would call attention to the following points for the guidance of those contemplating this method of reducing rail wear:

To secure the best results, oil should be applied to the wheels of every train using the portion of track protected.

Hand application of oil should be made on the high rail of curve. Rail where oil is so applied should be slightly flange worn as flanges will not pick up oil from new rail or relayer rail not flange worn.

Oil used should be special oil for this purpose, as ordinary oil, such as black oil, cup grease, etc., does not have proper viscosity to secure satisfactory results. These special oils are now on the market.

The distance that the oil is being carried and distributed by flanges can be readily determined and oiling stations placed accordingly. It should be borne in mind that oil must be applied more often in territory where there are many sharp curves.

On descending grades, where many brake applications are made, or where retainers are turned down, heat of the wheels will cause oil to disappear from the wheels and it must be applied frequently to properly lubricate the rail.

Some difficulty has been experienced in securing efficient winter-time oiling, both by hand and machine, especially in northern territory. Special grades of oil are now being made to meet this condition and the Committee feels that this problem will be solved in a short time. Attention is also called to the fact that the rail needs oiling to a less extent in winter than in summer, as the greater amount of rain, snow, etc., will naturally give some rail lubrication and the traffic is generally lighter in winter than in summer.

Several of the larger roads report that they are saving considerable sums in maintenance, due to oiling and are extending the practice to cover larger portions of the road. The Committee feels that with proper oiling, uniformly and consistently carried on, the rail on the high side of curves will give considerable increase in life and will effect a saving on roads with sharp curvature.

The Committee recommends that this report be received as information only and the subject be continued.

A

Exhibit A

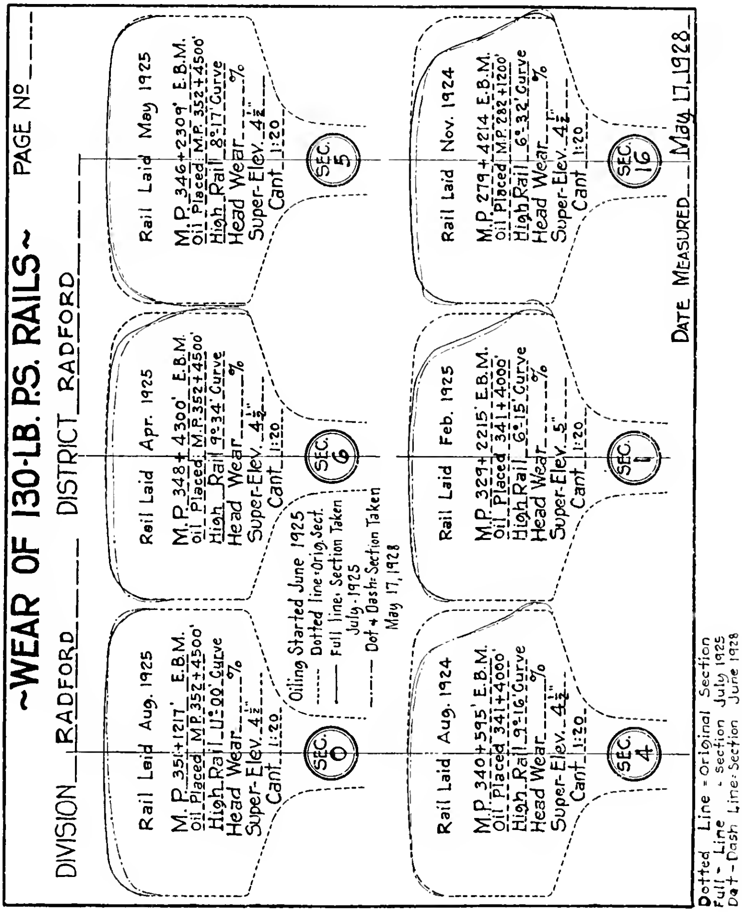

~WEAR OF 130-LB. P.S. RAILS~
PAGE No
DIVISION RADFORD
DISTRICT RADFORD
Rail Laid Aug. 1925
M.P. 351+1217' E.B.M.
Oil Placed M.P. 352+4500'
High Rail 11°00' Curve
Head Wear %
Super-Elev. 4½"
Cant 1:20
SEC. 0
Rail Laid Apr. 1925
M.P. 348+4300' E.B.M.
Oil Placed M.P. 352+4500'
High Rail 9°34' Curve
Head Wear %
Super-Elev. 4½"
Cant 1:20
SEC. 6
Rail Laid May 1925
M.P. 346+2309' E.B.M.
Oil Placed M.P. 352+4500'
High Rail 8°17' Curve
Head Wear %
Super-Elev. 4½"
Cant 1:20
SEC. 5
Oiling Started June 1925
Dotted line = Orig. Sect.
Full line = Section Taken July 1925
Dot & Dash = Section Taken May 17, 1928
Rail Laid Aug. 1924
M.P. 340+595' E.B.M.
Oil Placed 341+4000'
High Rail 9°16' Curve
Head Wear %
Super-Elev. 4½"
Cant 1:20
SEC. 4
Rail Laid Feb. 1925
M.P. 329+2215' E.B.M.
Oil Placed 341+4000'
High Rail 6°15' Curve
Head Wear %
Super-Elev. 5"
Cant 1:20
SEC. 1
Rail Laid Nov. 1924
M.P. 279+4214 E.B.M.
Oil Placed M.P. 282+1200'
High Rail 6°32' Curve
Head Wear %
Super-Elev. 4½"
Cant 1:20
SEC. 16
DATE MEASURED May 17, 1928
Dotted Line = Original Section
Full - Line = Section July 1925
Dot - Dash Line = Section June 1928

Exhibit B

	Section 0	Section 6	Section 5	Section 4	Section 1	Section 16
Alignment — Grade ("D" = descending)	0.9% D	0.48% D	0.78% D	1.07% D	Level	1.32% D.
Alignment — Curvature (All sections = high rails)	11°00'	9°34'	8°17'	9°16'	6°15'	6°32'
Alignment — Superelevation	4½"	4½"	4½"	4½"	5"	4½"
Distance - Oiling Point to Section - Miles	1.62	4.04	6.41	1.65	12.34	2.43
~Before Oiling~						
Million Gross Ton Miles Traffic	—	167.06	83.53	798.21	334.13	572.33
Square Inches of Rail Wear	—	0.083	0.045	0.270	0.250	0.283
Sq. In. Rail Wear per Million Gross Ton Miles	—	.000497	.000539	.000338	.000747	.000494
Rail in service	—	2 mo.	1 Mo.	10 Mo.	4 Mo.	7 Mo.
~After Oiling~						
Million Gross Ton Miles Traffic	3067.65	3233.52	3233.52	3233.52	3233.52	3233.52
Square Inches of Rail Wear	0.150	0.200	0.050	0.095	0.135	0.143
Sq. In. Rail Wear per Million Gross Ton Miles	.0000489	.0000618	.0000155	.0000294	.0000418	.0000443
Rail in service since oiling began—(months)	33	35	35	35	35	35
Ratio of Wear—Oiled rails to Unoiled Rails	—	1:8	1:34.8	1:11.5	1:17.8	1:11.1

COST OF OILING TO REDUCE RAIL WEAR ON CURVES

(Furnished by Norfolk & Western Railway)
Six Oiling Points Covered by Each Example

(A) Hand oiling, by regular watchman. No labor cost.

Oil 3,833 gallons at 25 cents	$ 958.25

(B) Hand oiling, ¼ laborer's time charged to oiling. Rate 38 cents per hour.

Annual labor	$ 4,993.20
Oil 3,833 gallons at 25 cents	958.25
	$ 5,951.45
Cost per gallon oil applied $1.55	

(C) Hand oiling, continuous laborers, no other duties assigned. Rate 38 cents per hour.

Annual labor	$19,972.80
Oil 3,833 gallons at 25 cents	958.25
	$20,931.05
Cost per gallon oil applied $5.46	

(D) Mechanical oiling.

Annual maintenance cost	$ 517.80
Labor servicing machines	832.20
Oil 3,288 gallons at 25 cents	822.00
	$ 2,172.00
Cost per gallon oil applied $0.66	

Saving in oil for machine lubrication as compared with hand oiling: Per year for 6 points, 545 gallons.

Appendix G

(7) CAUSE AND EFFECT OF BRINE DRIPPINGS

W. G. Arn, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, W. H. Bevan, H. W. Brown, J. W. DeMoyer, J. E. Deckert, C. J. Geyer, F. S. Hales, F. W. Hillman, E. T. Howson, C. R. Strattman, E. D. Swift, J. R. Watt.

The Sub-Committee found that there was a committee of the Mechanical Division of the American Railway Association which was already working on this subject, and it was deemed advisable for your Sub-Committee to work with that committee if it could be satisfactorily arranged. This arrangement was put into effect, and after several meetings of your Sub-Committee and joint meetings of the two committees, arrangements were made to send out a joint questionnaire as an inquiry of the American Railway Association.

The questionnaire is as follows:

"1. It is assumed that in the so-called brine tank type of refrigerator cars, i.e., cars designed for handling packing house products, salt is always used with the ice.

"In the open bunker type of refrigerator cars, i.e., those used for fruit and vegetables, the use of salt with the ice has been in effect only for the last few years.

"(a) In what proportion of the open bunker type of refrigerator cars handled over your line, is salt used with the ice?

"(b) Give percentage of salt used, if any.

"(c) Advise to what extent the practice of using ice and salt spread over the load is followed.

"2. (a) Is the rule requiring brine retainers on the meat type of refrigerator cars strictly enforced on your road?

"(b) What is being done, when cars equipped with brine retaining devices are received, to see that such devices are being maintained? What percentage is found defective?

"(c) If it has been your experience to find that brine retaining devices are not effective, what changes would you recommend to improve conditions?

"(d) To what extent have cars been found leaking brine from points other than retaining devices?

"3. (a) What damaging or destructive effects have resulted on your lines from brine drippings from refrigerator cars?

"(b) How serious is the damage on this account, especially with regard to decreased service life.

(1) To bridges?
(2) To rail and track fastenings?
(3) To signal and interlocking equipment?
(4) To other material or structures?

"4. If you were to place a money value on the loss due to damage and destruction from brine drippings, what would be your estimate per mile of track, including bridges, or in a lump sum for your lines?

"5. What measures have you taken or considered (as being worthy of being taken) to combat or overcome the deterioration on this account through the use of protective coatings or through the use of special metals. (Give names of coatings or metals.)

"6. What suggestions have you to offer for the betterment of conditions resulting from the deterioration attributed to brine drippings?"

This questionnaire went out so late, October 30th, that replies of roads having information on the subject had not begun to be received at the last meeting of your Committee prior to Committee Report going to press.

Conclusions

This report is submitted as information, and the reassignment of the subject is recommended.

Appendix H

(8) PREPARE PLANS AND SPECIFICATIONS FOR TRACK TOOLS

G. M. Strachan, Chairman, Sub-Committee; J. V. Neubert, C. R. Harding, J. B. Akers, W. H. Bevan, W. G. Brown, L. H. Bond, H. R. Clarke, L. W. Deslauriers, C. J. Geyer, J. B. Myers, T. P. Warren, J. R. Watt.

The plans covering the following tools, clay picks, tamping picks, spike mauls, wrenches, lining bars, rail tongs, tie tongs, spike pullers and rail forks, claw bars, adzes, sledges, mattocks, tamping bars, track chisels and punchers also specifications covering these tools and specifications for hickory handles for track tools, have been prepared in conference with the Forged Tool Society and reflect good engineering as well as good shop practice. Specifications covering handles have been developed in conference with the Hickory Handle Association and are based on the U.S. Department of Commerce Simplified Practice Bulletin No. 77, effective date Nov. 1st, 1927. Further, standardization has been worked out between the handle manufacturers and the forged tool manufacturers with respect to standard eye holes and plans submitted herewith are in conformance. Plan covering modified type track gage is also submitted. Further study will be given the subject of track tools in an endeavor to work up simplified standards covering track levels, ballast forks, track shovels, axes, scythes and other tools used in the Maintenance of Way Department.

Your Committee suggests that consideration be given to transferring all plans covering track tools from the Manual similar to the Association Track Portfolio portion of the Manual after necessary revisions have been made and final approval secured. Track tool plans published in such a manner would permit the making of revision as necessary and also allow for wider distribution and more general use of recommended A.R.E.A. standards.

Action Recommended

The Committee submits, herewith, certain track tool specifications and plans with recommendation that they be received as information with a view to superseding the plans and specifications now appearing in the Manual covering the same items.

The Committee recommends continuing the subject during the coming year.

The Committee on Track recommends that the following material in the Manual be withdrawn:

DESIGNS AND SPECIFICATIONS FOR TRACK TOOLS

(1) Specifications for Ballast Tools, page 88, Manual.

(2) Designs for Track Tools, Supplement to Manual, Bulletin 249, page 581.

(3) Specifications for Track Tools, Bulletin 267, page 25.

(4) Specifications for Hickory Handles for Track Tools, Supplement to Manual, Bulletin 287, page 39.

SPECIFICATIONS FOR HICKORY HANDLES FOR TRACK TOOLS

Handles shall conform to "Grades AW or AR" as set forth in Simplified Practice Recommendation No. 77 of the Bureau of Standards, United States Department of Commerce, effective November 1st, 1927.

PHYSICAL REQUIREMENTS

Handles shall be smooth, straight and for each type of tool, uniform in size and shape. The grain of the wood must run parallel to the center line of handle, with an allowable variation of not over one inch in fifty inches. Handles which are warped or twisted will not be accepted.

DESIGN

Handles shall conform to the dimensions shown on the plan forming part of this specification, with an allowable variation of one-quarter inch in length, and one-sixteenth inch over or under for all other dimensions.

MANUFACTURE

(a) Handles shall be smoothly finished and waxed.

(b) Each handle shall be plainly marked for identification by the purchaser with brand and identification mark, as specified by Simplified Practice Recommendation No. 77. Marking unless otherwise specified by purchaser shall be placed near the hand grasp end of handles and letters must not be less than three-sixteenths inch in height.

INSPECTION

(a) Handles will be inspected at points of manufacture, shipment or destination in suitable and convenient places satisfactory to the purchaser.

(b) Inspectors representing the purchaser shall have free entry to the works of the manufacturer at all times while work on the contract of the purchaser is being performed, and shall have all reasonable facilities afforded them, free of cost, to satisfy them that the handles are being supplied in accordance with these specifications.

(c) Inspectors will make a reasonably close examination of each handle and the acceptance or rejection will be based on the inspector's knowledge of the appearance and weight of wood of the density required, rings of annual growth will not be counted nor handles weighed by scale unless the inspector's decisions are questioned. Exactness of size and shape will be checked by accurate measurements of handles taken at random.

DELIVERY

Accepted handles shall be shipped by the seller in accordance with the instructions in the order covering them; they shall be securely packed in standard packages, each of which shall be marked to show seller's or manufacturer's name and the number, type and grade of the handles contained.

Note.—"Grades BW and BR" of the Simplified Practice Recommendation No. 77 of the Bureau of Standards, effective November 1st, may be specified if an inferior grade of timber is desired for the less important track tools.

TRACK TOOLS

GENERAL SPECIFICATIONS

Workmanship and Finish

Each tool shall be finished in a workmanlike manner and shall be free from flaws, seams, cracks, irregularities of shape, or other imperfections. Each tool shall be coated before leaving the factory with paint, oil or varnish, to prevent corrosion, and any polished cutting edges of tools shall be oiled.

Marking

Each tool shall be plainly stamped with the manufacturer's name or brand and the purchaser's initials.

Inspection

When required by the purchaser, the manufacturer shall furnish samples of material stock for testing before proceeding with the filling of the order and shall give sufficient notice in advance of the date when tools will be ready for inspection.

The inspector representing the purchaser shall have free access at all times while the work on the contract of the purchaser is being performed to all parts of the manufacturer's works which concern the manufacture of the material ordered.

The inspection shall be made at the plant prior to shipment and the manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy himself that the tools are being furnished in accordance with these plans and specifications. The tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works. The inspector shall select one finished tool from each ten dozen or less of purchase and the acceptance or rejection of each lot shall be determined by the result of the tests. Individual tools which develop defects due to poor material or faulty workmanship or which are found not to fulfill the requirements of these specifications shall be rejected and returned at the seller's expense.

In the detail specifications, the permissible variation must not be construed to change the shape and general contour of the tool as indicated on the plans.

When Brinell hardness tests are specified, other methods may be used, provided equal results are obtained.

Shipment or Delivery

Tools shall be properly packed for shipment to avoid damage. All bundles and boxes shall be plainly marked with the name of the purchaser, the name of the manufacturer, and the point of shipment.

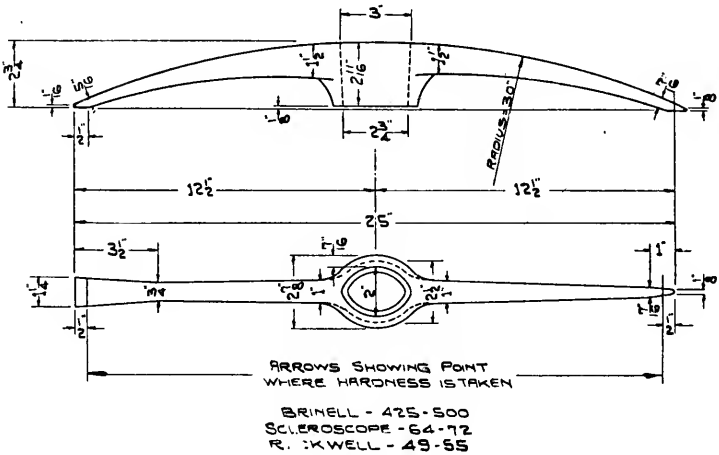
CHEMICAL & PHYSICAL SPECIFICATIONS

Tolerance on all Tools.

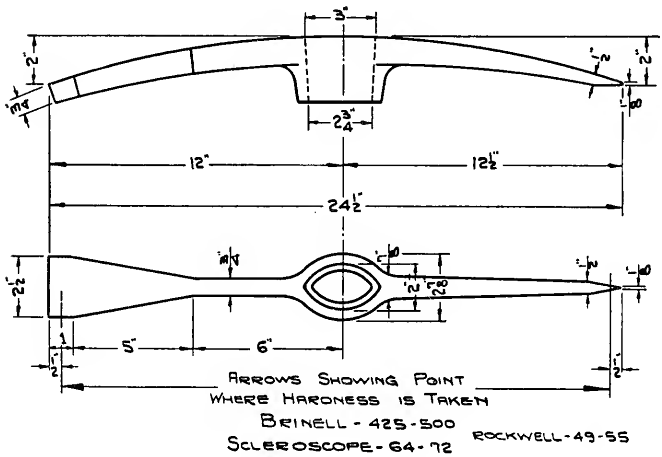
2% on the length
5% on the cross sections.

HIGH GRADE OPEN HEARTH.		COLD MELT ELECTRIC STEEL	
Carbon	.60 to .75	Carbon	.80 to .90
Manganese	.30 to .50	Manganese	.30 to .50
Phosphorus & Sulphur	-.050	Phosphorus & Sulphur	-.025
		Silicon	.10 to .20

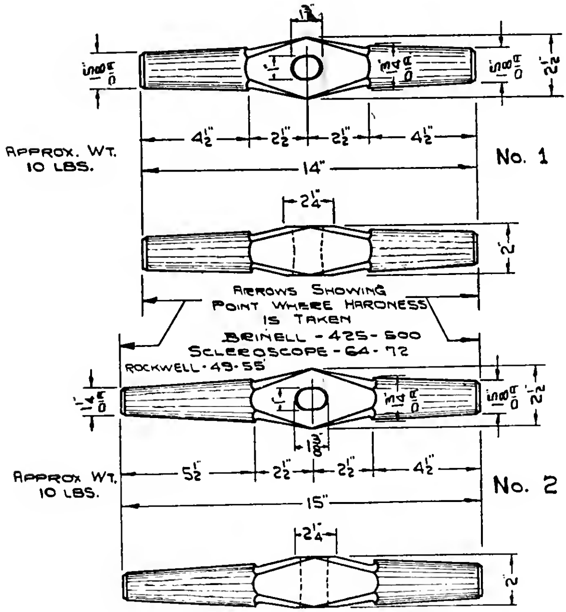
PAGE.	NAME	GRADE STEEL		BRINELL HARDNESS	SCLERO-SCOPE.	ROCKWELL
1	General Specifications.					
2	Chemical & Physical Specifications.					
3	Clay Picks	Open Hearth		425-500	64-72	49-55
4	Tamp Picks	O.H.		425-500	64-72	49-55
5	Spike Mauls	O.H.		425-500	64-72	49-55
6	Track Wrenches	O.H.		375-450	57-66	45-51
7	Lining and Pinch Bars	O.H.		None	None	None
8	Rail Tongs	O.H.		None	None	None
9	Tie Tongs One Man	O.H.		None	None	None
9	Tie Tongs Two Man	O.H.		None	None	None
10	Spike Pullers	O.H.		375-450	57-66	45-51
10	Rail Forks	O.H.		None	None	None
11	Claw Bars	O.H.		258-360	40-55	31-43
12	Adze	O.H.		375-450	57-66	45-51
13	Sledges	O.H.		425-500	64-72	49-55
14	Mattocks	O.H.		425-500	64-72	49-55
15	Chisel End Tamping Bar	O.H.		425-500	64-72	49-55
15	Spear End Tamping Bar	O.H.		425-500	64-72	49-55
16	Track Chisels,	Electric	(Point	477-532	70-75	54-57
			(Head	286-340	44-52	35-41
17	Tie Plug Punch,	Electric	(Point	477-532	70-75	54-57
			(Head	286-340	44-52	35-41
17	Rd. Track Punch,	Electric	(Point	477-532	70-75	54-57
			(Head	286-340	44-52	35-41
18	Track Gage	Cast		None	None	None
19-20	Comparative Hardness Tables.					



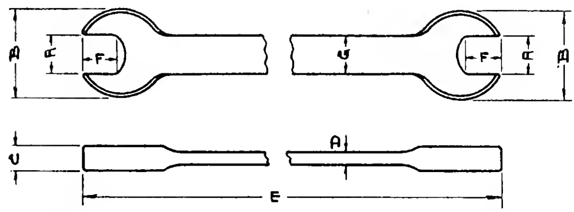
Clay Pick



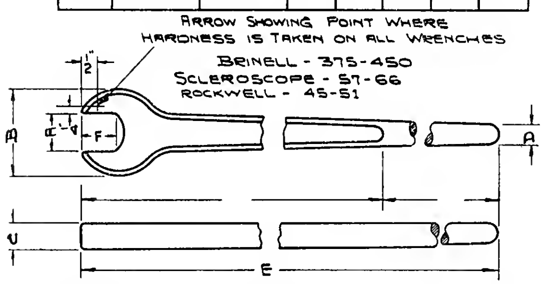
V Type Tamping Pick



Bell Pattern Spike Mauls

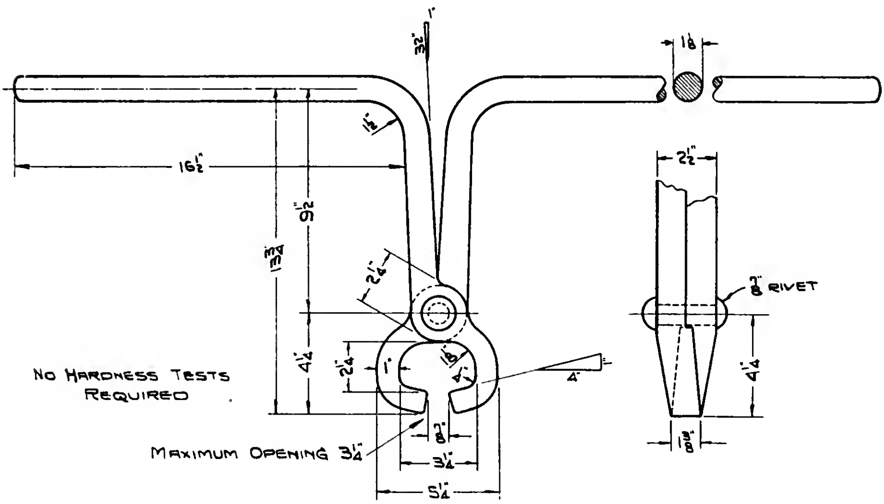


BOLT SIZES	A	B	C	D	E	F	G
3/4 × 7/8	1 5/16 × 1 1/2	3 1/2 × 4	7/8	1/2	36	1 1/4	1 1/2
7/8 × 1	1 1/2 × 1 11/16	4 × 4	7/8	1/2	36	1 1/4	1 1/2
1 × 1 1/8	1 11/16 × 1 7/8	4 × 4 1/8	7/8	9/16	42	1 3/8	1 1/2
1 1/8 × 1 1/4	1 7/8 × 2 1/16	4 1/8 × 4 1/4	15/16	9/16	42	1 3/8	1 1/2



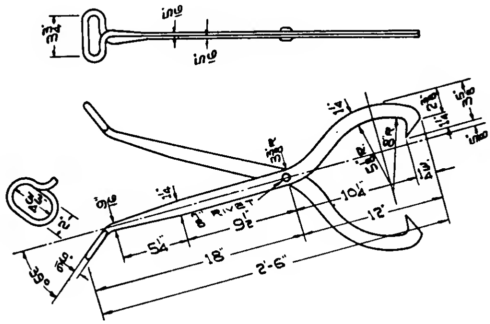
BOLT SIZES		A	B	C	D	E	F		
3/4		1 5/16	3 1/2	7/8	3/4	30	1 1/4		
7/8		1 1/2	4	7/8	3/4	30-36	1 1/4		
1		1 11/16	4	7/8	7/8	30-36	1 3/8		
1 1/8		1 7/8	4 1/8	15/16	7/8	36-42	1 3/8		
1 1/4		2 1/16	4 1/4	1	7/8	36-42	1 3/8		

WRENCH



1"
32"
1⅛
1½"
16½"
9½"
13¾
2¼"
2½"
⅞" RIVET
4¼"
2¼"
1"
⅛
4"
4"
No Hardness Tests Required
⅞"
Maximum Opening 3¼"
3¼"
5¼"
4¼"
1⅜"

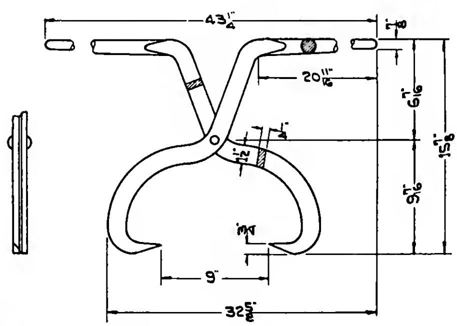
Rail Tongs



APPROX. WT. 7½ TO 8 LBS.

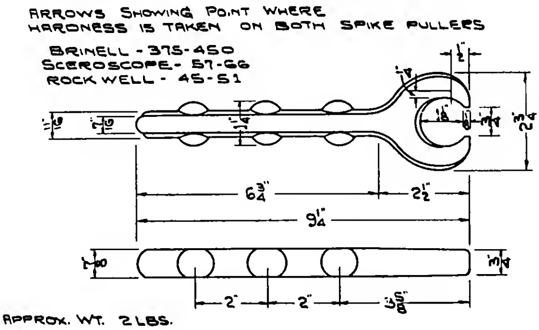
ONE-MAN TIE TONGS

NO HARDNESS TESTS REQUIRED ON TONGS

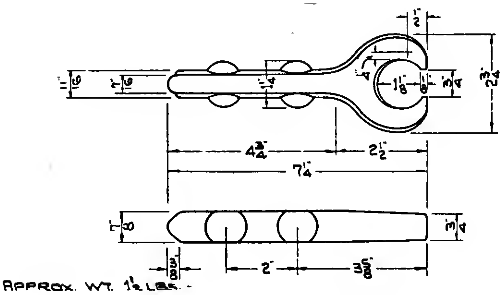


APPROX. WT. 17 LBS.

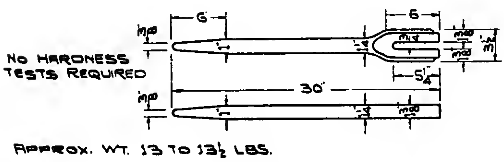
TWO-MAN TIE TONGS



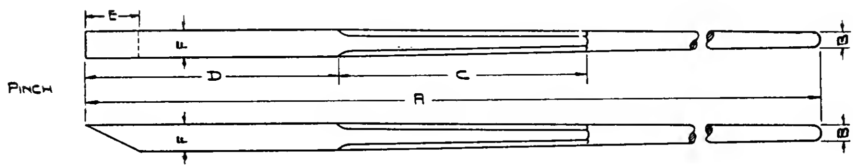
THREE BALL SPIKE PULLERS

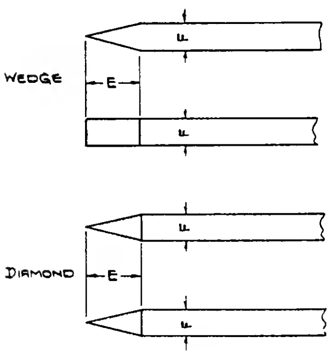


TWO BALL SPIKE PULLERS



RAIL FORK

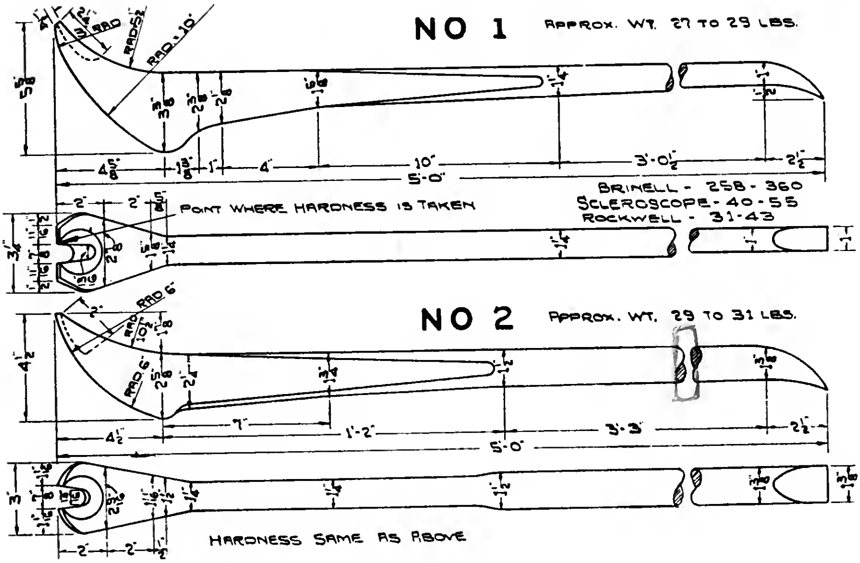




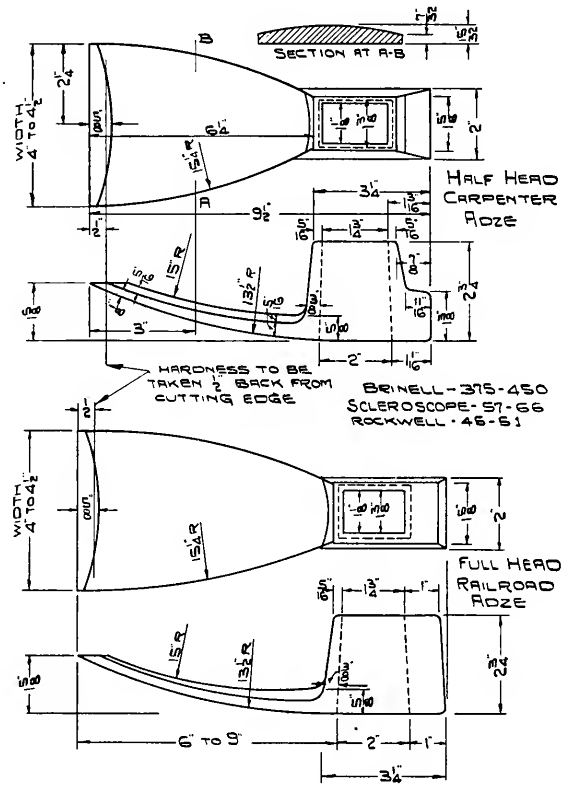
APPROX WT.	18 LB.	20 LB.	26 LB.
A	5'-0"	5'-3"	5'-6"
B	$\frac{3}{4}$"	$\frac{3}{4}$"	$\frac{7}{8}$"
C	14"	14	14
D	14	14	14
E	3	3	3
F	$1\frac{1}{4}$"	$1\frac{1}{4}$"	$1\frac{1}{2}$"

NO HARDNESS TESTS REQUIRED

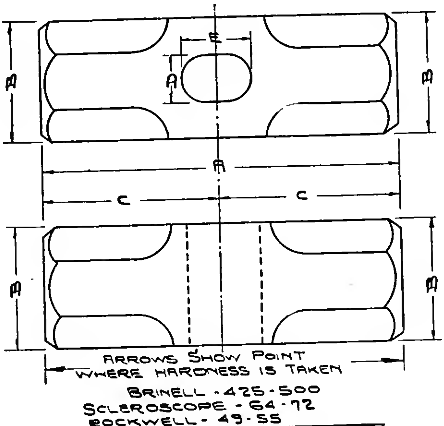
PINCH AND LINING BARS


NO 1
APPROX. WT. 27 TO 29 LBS.
BRINELL - 258 - 360
SCLEROSCOPE - 40 - 55
ROCKWELL - 31 - 43
POINT WHERE HARDNESS IS TAKEN
NO 2
APPROX. WT. 29 TO 31 LBS.
HARDNESS SAME AS ABOVE

Claws Bars


SECTION AT A-B
HALF HEAD CARPENTER ADZE
HARDNESS TO BE TAKEN ½" BACK FROM CUTTING EDGE
BRINELL - 375 - 450
SCLEROSCOPE - 57 - 66
ROCKWELL - 46 - 51
FULL HEAD RAILROAD ADZE
WIDTH 4" TO 4½"
6" TO 9"

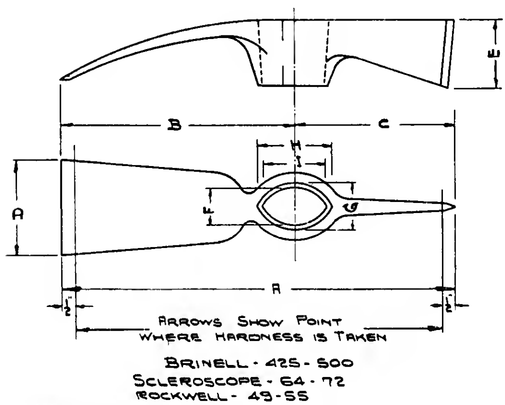
ADZE



SCHEDULE OF DIMENSIONS

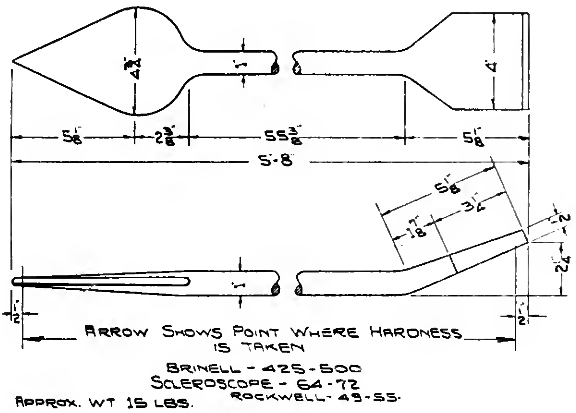
APPROX WT.		A	B	C	D	E
6 LB.		6	2⅛	3	1	1¼
8 LB.		6½	2¼	3¼	1	1¼
10 LB		7	2½	3½	1	1⅜
12 LB		7½	2⅝	3¾	1	1⅜
14 LB		8	2¾	4	1	1⅜
16 LB		8¼	2⅞	4⅛	1	1⅜
18 LB		8½	3	4¼	1¼	1½

DOUBLE FACE SLEDGE

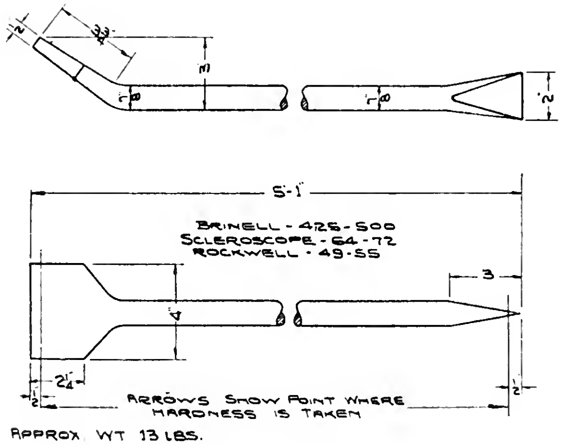


APPRO. WT.	A	B	C	D	E	F	G	H	I
5 LB.	15¾	9½	6¼	3½	3	1¾	2	3	2¾
6 LB.	16½	9¾	6¾	4	3	1¾	2	3	2¾

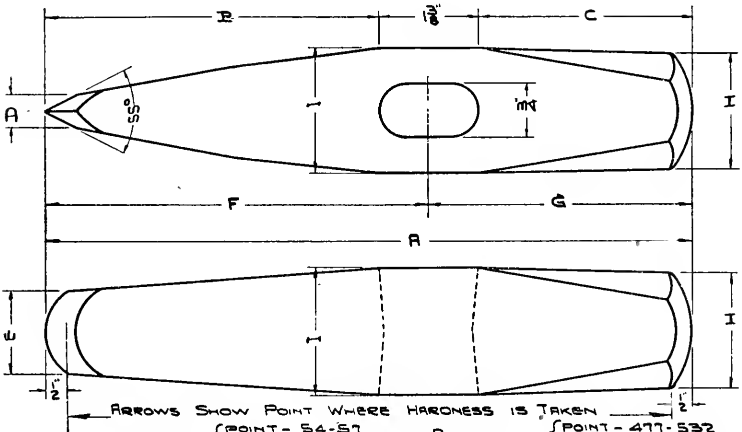
MATTOCKS



SPEAR END TAMPING BAR



CHISEL END TAMPING BAR

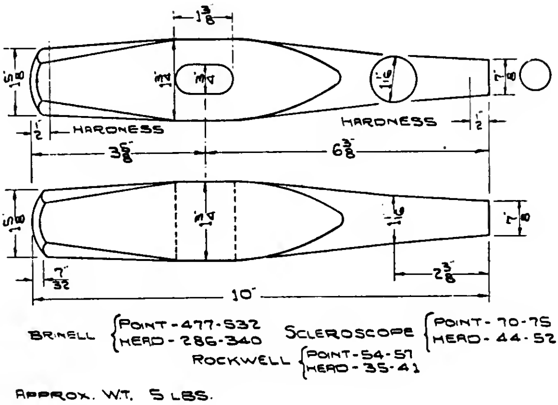


Rockwell { Point - 54-57, Head - 35-41 } Brinell { Point - 477-532, Head - 286-340 }

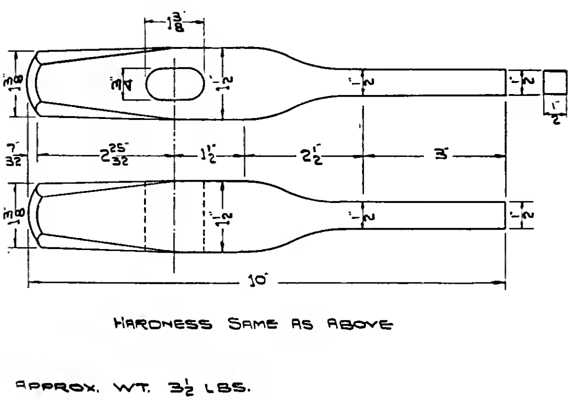
Scleroscope { Point - 70-75, Head - 44-52 }

Approx. Wt.	A	B	C	D	E	F	G	H	I
$5\frac{1}{2}$ lbs.	$9\frac{1}{4}$	$4\frac{7}{8}$	3	$\frac{7}{16}$	$1\frac{1}{8}$	$5\frac{9}{16}$	$3\frac{11}{16}$	$1\frac{9}{16}$	$1\frac{3}{4}$
$6\frac{1}{2}$ lbs	$10\frac{1}{2}$	$6\frac{1}{8}$	3	$\frac{7}{16}$	$1\frac{1}{8}$	$6\frac{13}{16}$	$3\frac{11}{16}$	$1\frac{9}{16}$	$1\frac{3}{4}$

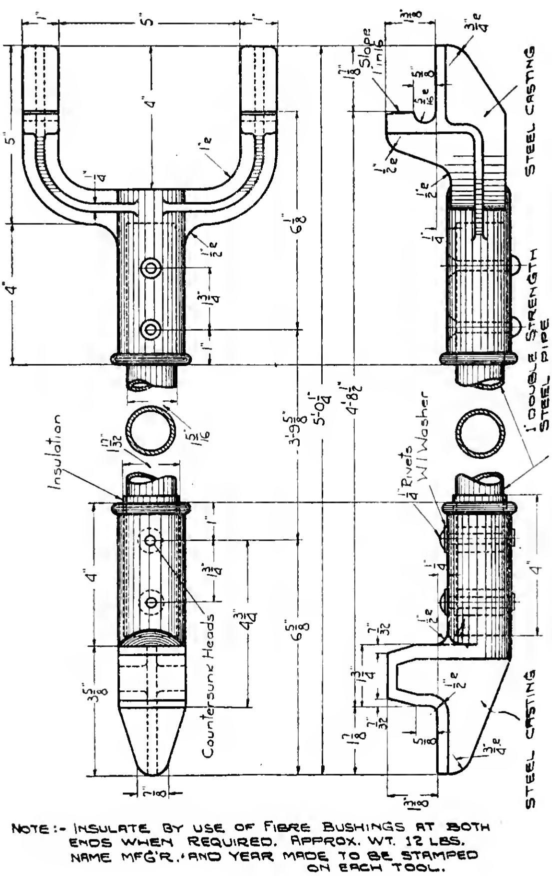
TRACK CHISELS



Round Track Punch



Tie Plug Punch


STEEL CASTING
1" DOUBLE STRENGTH STEEL PIPE
Insulation
Countersunk Heads
1/4" Rivets W/ I Washer
Slope 1 in 16
NOTE:- INSULATE BY USE OF FIBRE BUSHINGS AT BOTH ENDS WHEN REQUIRED. APPROX. WT. 12 LBS. NAME MFG'R. AND YEAR MADE TO BE STAMPED ON EACH TOOL.

TRACK GAGE

AMERICAN SOCIETY FOR STEEL TREATING

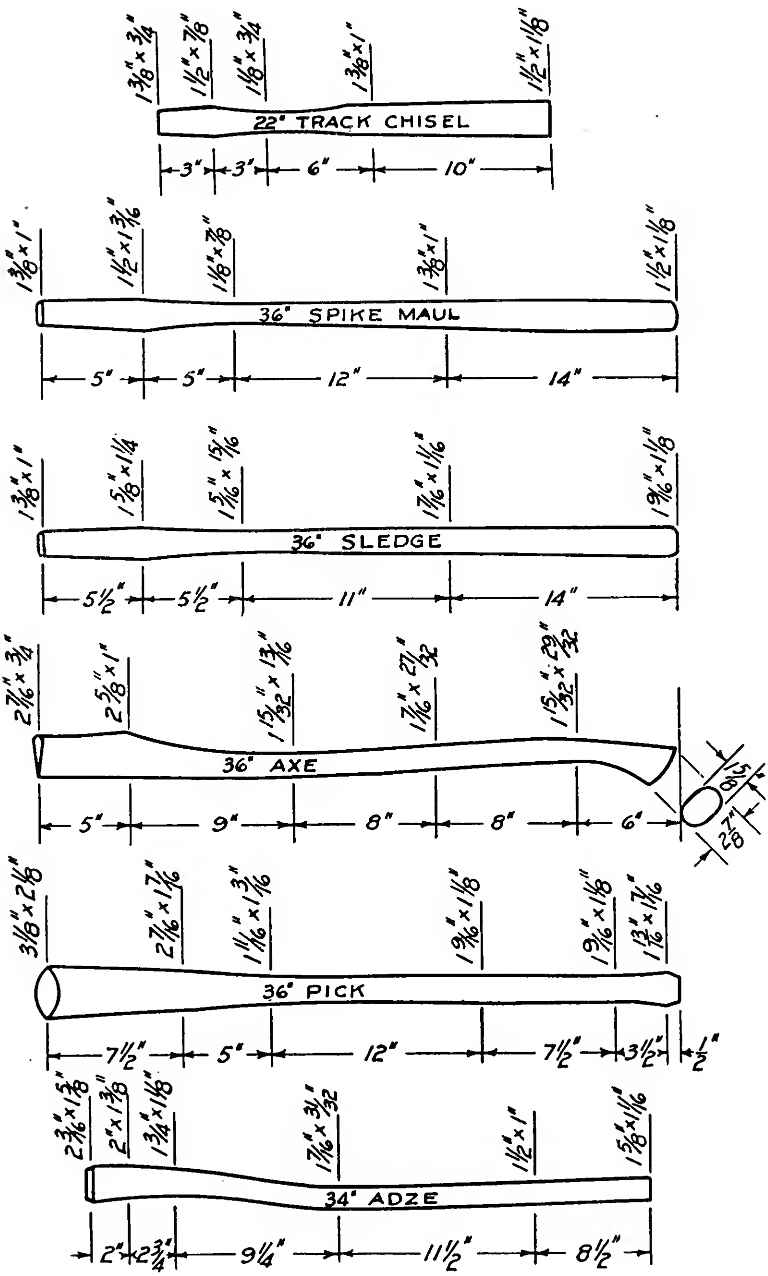
When Scleroscope Specifications call for	Start Tests on Rockwell Tested at (and read on C scale as Scleroscope Number.
95-105	C30
90-100	C26
85-95	C24
80-90	C22
75-85	C20
70-80	C18
65-75	C17
60-70	C15
55-65	C13
50-60	C11
45-55	C10
30-50	C 9
25-35	C10
20-30	C11
15-25	C13

CONVERSION TABLE #1

Rockwell C Scale 120 Degree Cone 150 Kilogram Load.	Scleroscope Average of Models C & D Scleroscope	Brinell Millimeter Diam. 10 Millimeter Ball - 3000 Kilogram Load.	Brinell Numbers.	Ultimate Strength Pounds per square inch.
70	98	2.25	745	366,600
69	96	2.255	725	357,000
68	94	2.30	712	350,600
67	92	2.35	682	335,700
66	90	2.375	668	327,000
65	88	2.40	654	323,000
64	87	2.45	627	300,840
63	85	2.475	614	390,000
62	83	2.50	602	265,000
61	82	2.525	590	290,000
60	80	2.55	578	284,300
59	78	2.60	555	273,300
58	77	2.625	545	268,000
57	75	2.65	534	263,000
56	74	2.70	514	254,000
55	72	2.725	504	248,600
54	71	2.75	495	243,800
53	69	2.80	478	235,000

AMERICAN SOCIETY FOR STEEL TREATING
CONVERSION TABLE #1 (continued)

Rockwell	Scleroscope	Brinell Millimeter diam.	Brinell Numbers	Pounds per square inch.
52	67	2.85	461	226,400
51	66	2.872	452	222,300
50	65	2.90	444	218,700
49	64	2.95	429	211,100
48	63	3.00	415	203,800
47	61	3.05	401	197,200
46	59	3.10	388	190,900
45	57	3.15	375	184,600
44	56	3.20	363	178,700
43	54	3.25	352	173,300
42	53	3.275	346	170,100
41	52	3.30	341	167,900
40	50	3.35	331	162,600
39	49	3.40	321	157,800
38	48	3.45	311	153,100
37	47	3.50	302	148,600
36	45	3.55	293	144,300
35	44	3.60	285	140,100
34	43	3.65	277	136,200
33	42	3.70	269	132,400
32	41	3.75	262	128,800
31	40	3.775	258	126,700
30	39	3.80	255	125,300
29	38	3.85	248	121,900
28	37	3.90	241	118,700
27	36	3.95	235	115,500
26	35	4.00	229	112,700
25	34	4.05	223	109,700
24	33	4.10	217	106,900
23	32	4.15	212	104,200
22	31	4.20	207	101,600
21	30	4.25	201	99,000
20	30	4.30	197	96,800
19	29	4.35	192	94,400
18	28	4.40	187	92,200
17	27	4.425	185	91,100
16	27	4.45	183	90,000
15	26	4.50	179	87,900
14	25	4.55	174	85,800
13	24	4.60	170	83,900
12	23	4.65	167	82,100
11	23	4.675	165	81,800
10	22	4.70	163	80,100



Track Tool Handles

Note.—Designs conform with Specifications of the Forged Tool Society covering eye holes.

REPORT OF COMMITTEE XV—IRON AND STEEL STRUCTURES

A. R. Wilson, *Chairman;*
P. S. Baker,
J. E. Bernhardt,
A. W. Carpenter,
O. F. Dalstrom,
R. P. Davis,
F. O. Dufour,
Thos. Earle,
G. H. Gilbert,
C. S. Heritage,
O. E. Hovey,
J. B. Hunley,
M. S. Ketchum,
W. S. Lacher,
P. B. Motley,
Albert Reichmann,
*A. F. Robinson,

G. A. Haggander, *Vice-Chairman;*
H. N. Rodenbaugh,
O. E. Selby,
I. L. Simmons,
C. E. Sloan,
P. B. Spencer,
S. M. Smith,
H. B. Stuart,
R. M. Stubbs,
G. H. Tinker,
G. H. Trout,
F. E. Turneaure,
F. P. Turner,
H. T. Welty,
W. L. Wilson,
W. M. Wilson,

Committee.

*Died, January 20, 1929.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(2) Specifications for Steel Highway Bridges (Appendix A).

(3) Feasibility of electric welding of connections in steel structures (Appendix B).

(7) Uses of copper bearing steel for structural purposes (Appendix C).

(8) Effect of dead load on impact from moving loads on bridges (Appendix D).

(9) Rolling Tests of Plates (Appendix E).

(10) Punched and Reamed Work (Appendix F).

Action Recommended

(2) That the report on specifications for steel highway bridges be approved and inserted in the Manual (Appendix A).

(3) That the report on the feasibility of electric welding of connections in steel structures be received as information (Appendix B).

(7) That the report on the uses of copper bearing steel for structural purposes be received as information (Appendix C).

(8) That the report on the effect of dead load on impact from moving loads on bridges be received as information (Appendix D).

(9) That the report on the allowable bearing pressures on large rollers be received as information (Appendix E).

(10) That the report on punched and reamed work be received as information (Appendix F).

Bulletin 314, February, 1929.

On Subject No. 1, Revision of the Manual, investigations and tests on a number of subjects are under way, including the allowable bearing pressures on large rollers, testing of I-beams in groups, investigating the economy in the use of copper bearing steel for structural purposes, effect of dead load on impact from moving loads. The work on these subjects has not progressed sufficiently to enable the Committee to make any recommendations for revision.

A Conference Committee composed of members of Committee XV and representatives of the American Society of Civil Engineers have been diligently at work drafting Specifications for Steel Railway Bridges. This work has been practically completed and it is expected that the Committee will present this year the Specifications to their respective organizations for adoption.

No definite progress was made during the year on the other three subjects of the Committee's Outline of Work given below:

(4) Undertake the study and behavior of bridge pins under test loads.

(5) Report on test of I-beams in groups.

(6) Undertake the testing and study the behavior of steel columns under test loads.

Recommendations for Future Work

The Committee recommends the reassignment of the following subjects in the form given:

1. Revision of Manual.
2. Make final report upon proposed specifications for steel highway bridges.
3. Study and report upon the feasibility of electric welding of connections in steel structures.
4. Undertake the testing and study the behavior of bridge pins under test loads.
5. Report on tests of I-beams in groups.
6. Undertake the testing and study the behavior of steel columns under test loads.
7. Investigate the desirability of using copper bearing steel for structural purposes.
8. Study the influence of the dead load upon the impact from moving loads on bridges.
9. Make a final report on bearing pressures on large rollers.
10. Punched and reamed work.
11. Outline of work for ensuing year.

The following new subjects are recommended:

1. Study longitudinal forces as applied to railroad bridge superstructures and substructures.
2. Develop design for rivet heads.

Respectfully submitted,

THE COMMITTEE ON IRON AND STEEL STRUCTURES,

A. R. WILSON, *Chairman.*

Appendix A

(2) SPECIFICATIONS FOR STEEL HIGHWAY BRIDGES

J. B. Hunley, Chairman, Sub-Committee; R. P. Davis, Albert Reichmann, A. F. Robinson, O. E. Selby, H. B. Stuart, H. T. Welty.

Your Committee submits herewith revised Specifications for Steel Highway Bridges for approval and publication in the Manual.

SPECIFICATIONS FOR STEEL HIGHWAY BRIDGES

1929

FOREWORD

Compiled by a Conference Committee composed of representatives from the American Association of State Highway Officials and the American Railway Engineering Association.

In scope these specifications are limited to the field of ordinary highway bridges and do not provide for unusual span lengths and types of construction for which provision must be made by special supplemental specifications.

SPECIFICATIONS FOR STEEL HIGHWAY BRIDGES

CONTENTS

Section	*Subject*	*Articles*
I	General Requirements and Basis of Payment	101- 114
II	Materials	201- 205
III	Workmanship	301- 336
IV	Mill and Shop Inspection	401- 406
V	Full-Size Tests of Eye-Bars	501- 506
VI	Shop Painting	601- 612
VII	Weighing, Marking and Shipping	701- 703
VIII	Erection	801- 820
IX	Field Painting	901- 904
X	General Features of Design	1001-1011
XI	Loads	1101-1118
XII	Distribution of Loads	1201-1203
XIII	Unit Stresses	1301-1306
XIV	Proportioning of Parts	1401-1417
XV	General Details of Design	1501-1536
XVI	Floor System	1601-1609
XVII	Bracing	1701-1708
XVIII	Plate Girders	1801-1812
XIX	Trusses	1901-1912
XX	Viaducts	2001-2009

INFORMATION TO BE GIVEN BIDDERS

Article

1. Is the bridge to be designed by the Contractor? 102
2. Is the bridge to be erected by the Contractor? 102
3. Furnish plans showing conditions at the site and general dimensions and conditions governing the design, such as: 102
   - (a) Width of roadway 1002
   - (b) Number and width of sidewalks, if any 1002
   - (c) Clearances 1003
   - (d) Height of curb 1004
   - (e) Kind of pavement 1007
   - (f) Utilities to be provided for, if any 1009
   - (g) Lengths and types of spans 1010
   - (h) Classification, loading and stresses 1011, 1107, 1301
   - (i) Number and width of electric railway tracks, if any 1111
   - (j) Loading for electric railway tracks 1111
   - (k) Alinement 1003
   - (l) Grades 1534
   - (m) Angle of skew 1605
   - (n) Limiting under clearance, as affected by highwater, railroads, or other highways 1411, 1601
4. Will payment be on a pound price or a lump sum basis? 110
5. Will scale weights or computed weights be the basis of payment? .. 112
6. Will general reaming be required? 308, 315
7. In punched work, will assembling of parts for reaming of field connections be required? 315
8. Will bolted connections be permitted? 319
9. Will facing of abutting joints of tension members be required? 323
10. Will other than two pilot and driving nuts for pins be required? .. 336
11. Will full-size tests of eye-bars be required? 501
12. Is shop painting included in the contract? 601
13. Is the old structure to be removed by the Contractor? 803, 816
14. Is the old structure to be reerected? 816
15. Is the old structure to be the property of the Purchaser? 816
16. Is the Contractor to receive the materials loaded or unloaded, and at what place? 805
17. Will falsework plans be required? 807
18. Is the Contractor to do the field painting? 901
19. Is the field painting to consist of other than two coats? 903
20. Are name plates to be furnished? 1536

SPECIFICATIONS FOR STEEL HIGHWAY BRIDGES—1929

Section I

GENERAL REQUIREMENTS AND BASIS OF PAYMENT

Definitions of Terms

101. The term "Purchaser" means the individual, company, or public authority contracting for the construction of a bridge under these specifications.

The term "Contractor" means the individual, partnership, or corporation contracting to construct a bridge under these specifications.

The term "Engineer" means the engineer representing the Purchaser. The Engineer may act directly or through an authorized representative.

The term "Inspector" means the inspector authorized to represent the Engineer.

Proposals

102. Proposals preferably shall be based on plans and specifications furnished by the Purchaser. If the bridge is to be designed or erected by the Contractor, the invitation to bidders shall give information as to conditions at the site.

Drawings

103. Before any work is begun under the contract, the Contractor shall submit to the Engineer for approval, prints of stress sheets and shop drawings, unless such drawings have been prepared by the Purchaser. These prints shall be in duplicate unless more are specified. Tracings of these drawings, in ink on tracing cloth, shall, if required, be delivered to the Engineer upon completion of the work and be the property of the Purchaser.

104. Changes on approved drawings shall be subject to the approval of the Engineer, and he shall be supplied with a record of such changes.

105. Substitutions of sections different from those shown on the drawings shall be made only when approved in writing by the Engineer.

106. The Contractor shall be responsible for the correctness of his drawings, and for shop fits and field connections, although the drawings may have been approved by the Engineer.

107. Any material ordered or work done by the Contractor before the drawings have been approved, shall be at his risk.

108. If the drawings and specifications differ, the drawings shall govern.

Patented Devices

109. The Contractor shall protect the Purchaser against claims on account of patented devices or parts used by the Contractor unless such use has been specified by the Purchaser.

Basis of Payment

110. The contract price for fabrication and erection of structural steel shall include all labor, materials, transportation, and shop and field painting necessary for the proper completion of the work in accordance with the contract.

The contract price for fabrication without erection shall include all labor and materials necessary for fabrication, shop painting, shipping and delivery at the place designated.

Payment will be made on a pound-price or a lump-sum basis, as required by the terms of the contract. For the purpose of payment, such items as bearing plates, pedestals, etc., shall, unless otherwise provided, be considered as structural steel even though made of other materials.

Payment for Test Eye-Bars

111. Full-size eye-bars which are tested and meet the requirements of these specifications shall be paid for by the Purchaser at the same rate as for the structure. Bars which fail to meet these requirements, and all bars rejected as a result of tests, shall not be paid for by the Purchaser.

Pay Weight

112. The payment in pound-price contracts shall be based on the weight of metal in the fabricated structure, including field rivets shipped. The weight of erection bolts, field paint, boxes, crates, and other containers used for packing, and materials used for supporting members during transportation, shall not be included.

Any weight in excess of 1½ per cent above the computed weight shall not be included in the pay weight.

The weight paid for shall be the shop scale weight unless otherwise provided. If specified in the contract or permitted by the Engineer, computed weights, obtained as hereinafter described, may be made the basis of payment.

Variance in Weight

113. If the scale weight of any member is less than 97½ per cent of the computed weight, the member may be rejected. This applies to both pound-price and lump-sum contracts.

Computed Weight

114. The computed weight shall be obtained by the use of the following rules and assumptions:

(a) The weight of steel shall be assumed at 0.2833 lb. per cubic inch. The weight of cast iron shall be assumed at 0.26 lb. per cubic inch. The weight of bronze shall be assumed at 0.315 lb. per cubic inch.

(b) The weights of rolled shapes, and of plates up to and including 36 inches in width, shall be computed on the basis of their nominal weights and dimensions, as shown on the approved shop drawings, deducting for copes, cuts, and open holes.

To the nominal weights of plates more than 36 inches in width, there shall be added one-half of the allowed percentage of overrun in weight given in the Specifications for Structural Steel, described in Article 201.

(c) The weight of heads of shop-driven rivets shall be included in the computed weight, assuming the weights to be as follows:

Diameter of rivet	*Weight of 100 heads, pounds*
½ inch	4.0
⅝ inch	7.5
¾ inch	12.5
⅞ inch	18.5
1 inch	27.0

(d) The weight of castings shall be computed from the dimensions shown on the approved shop drawings, with an addition of 10 per cent for fillets and overrun.

(e) To the total computed weight of metal may be added 0.4 of one per cent as an allowance for shop paint.

Section II

MATERIALS

Structural and Rivet Steel

201. Structural and rivet steel shall conform to the requirements of the Standard Specifications for Structural Steel for Bridges, Serial Designation A7-24, of the American Society for Testing Materials, with revisions thereof adopted by that Society.

Steel Castings

202. Steel castings shall conform to the requirements of the Standard Specifications for Steel Castings, Serial Designation A27-24, of the American Society for Testing Materials, with revisions thereof adopted by that Society, except that steel produced by the converter process shall not be used.

Castings shall be Class B, Medium Grade.

Gray-Iron Castings

203. Gray-iron castings shall conform to the requirements of the Standard Specifications for Gray-Iron Castings, Serial Designation A48-18, of the American Society for Testing Materials, with revisions thereof adopted by that Society.

Malleable Castings

204. Malleable castings shall conform to the requirements of the Standard Specifications for Malleable Castings, Serial Designation A47-24,

of the American Society for Testing Materials, with revisions thereof adopted by that Society.

Phosphor-Bronze

205. Phosphor-bronze shall conform to the requirements of the Standard Specifications for Bronze Bearing Metals for Turntables and Movable Railroad Bridges, Serial Designation B22-21, of the American Society for Testing Materials, with revisions thereof adopted by that Society.

Grade B metal shall be used.

Section III

WORKMANSHIP

Quality of Workmanship

301. Workmanship and finish shall be equal to the best general practice in modern bridge shops.

Storage of Materials

302. Structural material, either plain or fabricated, shall be stored at the bridge shop above the ground upon platforms, skids, or other supports. It shall be kept free from dirt, grease and other foreign matter, and shall be protected as far as practicable from corrosion.

Straightening Material

303. Rolled material before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends may be cause for rejection of the material.

Finish

304. Portions of the work exposed to view shall be finished neatly. Shearing and chipping shall be done carefully and accurately.

Punched Work

305. If general reaming is not required, all main material, forming parts of a member composed of not more than 5 thicknesses of metal, may be punched with a punch $\frac{1}{16}$ in. larger than the nominal size of the rivets, whenever the thickness of the metal is not greater than $\frac{3}{4}$ in. When there are more than 5 thicknesses, or when any of the main material is thicker than $\frac{3}{4}$ in., all of the holes shall be punched with a punch $\frac{3}{16}$ in. smaller, and after assembling reamed $\frac{1}{16}$ in. larger than the nominal size of the rivets, except that when the metal is thicker than the size of the rivet, the holes shall be drilled.

Punched Holes

306. Holes punched full-size shall be $\frac{1}{16}$ inch larger than the nominal diameter of the rivet. The diameter of the die shall not exceed the diameter of the punch by more than $\frac{3}{32}$ inch. Holes shall be clean cut and without torn or ragged edges.

Accuracy of Punched Holes

307. The punching of holes shall be done so accurately that, after assembling the component parts of a member, a cylindrical pin ⅛ inch smaller than the nominal diameter of the punched hole may be passed through at least 75 of any group of 100 contiguous holes, or in like proportion for any smaller group of holes. If this requirement is not fulfilled, the badly punched pieces may be rejected. If 10 per cent of any group of 100 or fewer holes will not pass a pin 3/16 inch smaller than the nominal diameter of the punched hole, the mispunched pieces may be rejected.

Reamed Work

308. General reaming will be required if provided for in the contract.

If general reaming is required, holes shall be sub-punched and reamed in material forming a part of the section of main members if the thickness of the material is not greater than the nominal diameter of the rivet. Holes may be punched full size in material used for lateral, longitudinal, and sway bracing, lacing bars, stay plates, and diaphragms, not forming a part of the section of main members if the thickness of the material is not greater than the nominal diameter of the rivet. Holes shall be drilled in material, the thickness of which is greater than the nominal diameter of the rivet.

Sub-Punched Holes

309. Sub-punched and reamed holes for rivets having diameters greater than ¾ inch shall be punched 3/16 inch smaller than the nominal diameter of the rivet. For rivets having diameters of ¾ inch, the holes shall be punched 11/16 inch in diameter. For rivets having diameters of ⅝ inch or less, the holes shall be punched full size and spear-reamed. The punch and die shall have the same relative sizes as specified for full size punched holes.

Reaming

310. After assembling, sub-punched holes shall be reamed to a diameter 1/16 inch larger than the nominal diameter of the rivet.

Reaming shall be done after the pieces forming a built member are assembled and firmly bolted together. Reamed parts shall not be interchanged.

Reaming of rivet holes shall be done with twist drills or with short taper reamers. Reamers preferably shall not be directed by hand. If oil or grease is used as a lubricant when reaming, it shall be applied so as not to soil surfaces which are to be painted. Burrs resulting from reaming shall be removed.

Drilled Holes

311. Drilled holes shall be 1/16 inch larger than the nominal diameter of the rivet. Burrs on the outside surfaces shall be removed. If members are drilled while assembled, the parts shall be held securely together while the drilling is being done.

Accuracy of Reamed and Drilled Holes

312. Reamed or drilled holes shall be cylindrical and perpendicular to the member. After reaming or drilling, 85 of any group of 100 contiguous holes, or in like proportion for any smaller group of holes, shall not show an offset greater than $\frac{1}{32}$ inch between adjacent thicknesses of metal.

Shop Assembling

313. Surfaces of metal in contact shall be cleaned before assembling.

The parts of a member shall be assembled, well pinned, and firmly drawn together with bolts before reaming or riveting is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation. The member shall be free from twists, bends, and other deformation.

Preparatory to the shop riveting of material punched full size, the rivet holes, if necessary, shall be spear-reamed for the admission of the rivets. The reamed holes shall not be more than $\frac{3}{32}$ inch larger than the nominal diameter of the rivets.

End connection angles, stiffener angles, and similar parts shall be carefully adjusted to correct position and bolted, clamped, or otherwise firmly held in place until riveted.

Parts not completely riveted in the shop shall be secured by bolts in so far as practicable to prevent damage in shipment and handling.

Drifting of Holes

314. The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. If any holes must be enlarged to admit the rivets, they shall be reamed.

Reaming of Field Connections

315. If general reaming is required, riveted trusses and skew portals shall be assembled in the shop, the parts adjusted to line and fit, and holes for field connections drilled or reamed while so assembled. Holes for other field connections, except those in lateral, longitudinal, and sway bracing, shall be drilled or reamed in the shop with the connecting parts assembled, or else drilled or reamed to a metal template without assembling.

If provided in the contract, the field connections in punched work, except those for lateral, longitudinal and sway bracing, shall be reamed to a metal template or else with the parts assembled.

Match-Marking

316. Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be match marked, and a diagram showing such marks shall be furnished to the Engineer.

Rivets

317. Rivets before driving shall be of the diameter specified. They shall be free from furnace scale.

Rivet heads shall be of approved shape, concentric with the shank, true to size, full, neatly formed, and free from fins.

Field Rivets

318. Field rivets shall be furnished in excess of the nominal number required to the amount of 10 per cent plus 10 rivets for each diameter and length.

Field Bolts

319. Bolted connections shall not be used unless specifically authorized. If bolted connections are permitted, the bolts shall be unfinished bolts or turned bolts, as specified. Bolts shall have hexagonal heads and nuts and shall be of such length that they will extend entirely through the nut but not more than ¼ inch beyond. Bolts in tension shall have two nuts.

Unfinished bolts in shear shall have not more than one thread within the grip. The diameter of the unfinished bolt shall not be more than $\frac{1}{16}$ inch smaller than the diameter of the hole.

The threads of turned bolts shall be entirely outside the grip. The bolts shall be given a finishing cut. Approved nut locks or flat washers ¼ inch thick shall be furnished, as specified. The holes for turned bolts shall be reamed and their diameters shall be not more than $\frac{1}{32}$ inch greater than the diameter of the finished bolt.

Riveting

320. Rivets shall be heated uniformly to a light cherry-red color and shall be driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale, and other adhering matter. When driven, they shall completely fill the holes. The heads shall be of approved shape, full size, neatly formed, concentric with the shank, free from fins, and in full contact with the surface of the member.

Loose, burned or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal, and, if necessary, they shall be drilled out. Caulking or recupping will not be permitted.

Rivets shall be driven by direct-acting riveters where practicable. The riveters shall retain the pressure after the upsetting is completed. If rivets are driven with a pneumatic hammer, a pneumatic bucker shall be used if practicable.

Edge Planing

321. Sheared edges of plates more than ⅝ inch in thickness and carrying calculated stress shall be planed to a depth of ¼ inch. Reentrant cuts shall be filleted before cutting.

Facing of Bearing Surfaces

322. The top and bottom surfaces of steel slabs and base plates and cap plates of columns and pedestals shall be planed, or else the plates or

slabs hot straightened. Parts of members in contact with them shall be faced.

Sole plates of beams and girders shall have full contact with the flanges. Sole plates and masonry plates shall be planed or hot straightened. Cast pedestals shall be planed on surfaces to be in contact with steel and shall have the surface to be in contact with masonry, rough finished.

Surfaces of bronze bearing plates intended for sliding contact, shall be finished.

In planing the surfaces of expansion bearings the cut of the tool shall be in the direction of expansion.

Abutting Joints

323. Abutting joints in compression members and girder flanges, and, in tension members where so specified on the drawings, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed ¼ inch.

Web Plates

324. Floor beams, stringers, and girders having end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the finished thickness of the angles shall be not less than that shown on the detail drawings.

Lacing Bars

325. The ends of lacing bars shall be neatly rounded unless another form is required.

Finished Members

326. Finished members shall be true to line and free from twists, bends, and open joints.

Web Plates

327. In girders having no cover plates and not to be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles, and shall not be more than ⅛ in. below at any point. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of the angles. Web plates of girders having cover plates may be ½ inch less in width than the distance back-to-back of flange angles.

At web splices, the clearance between the ends of the web plates shall not exceed ⅜ inch. The clearance at the top and bottom ends of web splice plates shall not exceed ¼ inch.

Fit of Stiffeners

328. End stiffener angles of girders and stiffener angles intended as supports for concentrated loads shall be milled or ground to secure an even bearing against the flange angles. Intermediate stiffener angles shall fit sufficiently tight to exclude water after being painted. Fillers under stiffeners shall fit within ¼ inch at each end.

Eye-Bars

329. Eye-bars shall be straight, true to size, and free from twists, folds in the neck and head, and other defects. The heads shall be made by upsetting and rolling or forging, and not by welding. The form of the heads will be determined by the dies in use at the works where the eye-bars are made, if they are satisfactory to the Engineer. The thickness of the head and neck shall not overrun more than $\frac{1}{16}$ in.

Eye-bars that are to be placed side by side in the structure shall be bored so accurately that upon being placed together, pins $\frac{1}{32}$ in. less in diameter than the pin holes will pass through the holes at both ends at the same time without driving.

Annealing

330. Before boring, eye-bars shall be annealed to produce the required physical qualities and shall be straightened. Proper instruments shall be provided for determining at any time the temperature of the bars.

Other steel that has been heated partially shall be annealed, unless it is to be used in minor parts. Crimped stiffeners need not be annealed.

Pins and Rollers

331. Pins and rollers shall be accurately turned to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. The final surface shall be produced by a finishing cut.

Pins more than 7 inches in diameter shall be forged and annealed.

In pins larger than 9 inches in diameter, a hole not less than 2 inches in diameter shall be bored full length along the axis.

Boring Pin Holes

332. Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

The distance outside-to-outside of holes in tension members and inside-to-inside of holes in compression members shall not vary from that specified more than $\frac{1}{32}$ inch. Boring of holes in built up members shall be done after the riveting is completed.

Pin Clearances

333. The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins 5 inches or less in diameter, or $\frac{1}{32}$ inch for larger pins.

Welds

334. Welding of steel shall not be done except to remedy minor defects and then only with the approval of the Engineer.

Screw Threads

335. Screw threads shall make close fits in the nuts and shall be U.S. Standard, except that for pin ends of diameters greater than 1½ inches, they shall be made with 6 threads to the inch.

Pilot and Driving Nuts

336. Two pilot nuts and two driving nuts for each size of pin shall be furnished, unless otherwise specified.

Section IV

MILL AND SHOP INSPECTION

Notice of Beginning of Work

401. The Contractor shall give the Engineer ample notice of the beginning of work at the mill or in the shop, so that inspection may be provided. The term mill means any rolling mill or foundry where material for the work is to be manufactured. No material shall be manufactured or work done in the shop before the Engineer has been so notified.

Facilities for Inspection

402. The Contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop, and the Inspectors shall be allowed free access to the necessary parts of the works.

Inspector's Authority

403. The Inspector shall have the authority to reject any material or work which does not meet the requirements of these specifications. In case of dispute the Contractor may appeal to the Engineer, whose decision shall be final.

Mill Orders and Shipping Statements

404. The Contractor shall furnish the Engineer with as many copies of mill orders and shipping statements as the Engineer may direct. The weights of the individual members shall be shown on the statements.

Facilities for Testing

405. The Contractor shall furnish test specimens, as specified herein, without extra charge; also the labor, testing machines and tools necessary to make the specimen and full size tests.

Rejections

406. The acceptance of any material or finished members by the Inspector shall not be a bar to their subsequent rejection, if found defective. Rejected material and workmanship shall be replaced promptly or made good by the Contractor.

Section V

FULL-SIZE TESTS OF EYE-BARS

Full-Size Tests

501. If tests of full-size eye-bars are required, they shall be made under the following conditions and requirements:

Number and Size of Test Bars

502. The number and size of the bars to be tested shall be stipulated by the Engineer before the mill order is placed. The number shall not exceed 5 per cent of the whole number of bars ordered, with a minimum of two bars.

Selection of Test Bars

503. The test bars shall be of the same section as the bars to be used in the structure and of the same length if within the capacity of the testing machine. They shall be selected by the Inspector from the finished bars. Test bars representing bars too long for the testing machine shall be selected from the full-length bar material after the heads on one end have been formed. Then they shall be cut and the second head formed, making a bar of the greatest length that can be tested.

Physical Requirements

504. Full-size tests of eye-bars shall show a yield point of not less than 33,000 pounds per square inch, an ultimate strength of not less than 60,000 pounds per square inch, and an elongation, including the fracture, of not less than 12 per cent in a length of 18 feet measured in the body of the bar. The fracture shall show a uniform silky or fine granular structure throughout.

Failure to Fulfill Requirements

505. If a bar fails to fulfill the specified requirements, two additional bars of the same size and from the same mill heat shall be tested. The bars represented by the test may be reannealed before the additional bars are tested.

If two of the three bars tested fail, the bars of that size and mill heat shall be rejected.

A failure in the head of a bar shall not be cause for rejection if the other requirements are fulfilled.

Record of Annealing

506. A record of the annealing furnace charges, showing the bars in each charge and the details of the treatment as to temperature and time, shall be furnished to the Engineer.

Section VI

SHOP PAINTING

General Conditions

601. The painting of metal structures shall include, unless otherwise provided in the contract, the preparation of the metal surfaces, the application, protection, and drying of the paint coatings, and the supplying of all tools, tackle, scaffolding, labor, and materials necessary for the entire work.

Paint

602. The paint used shall be that specified or approved by the Engineer.

Mixing of Paint

603. Paint shall be thoroughly mixed before applying, and the pigments shall be kept in suspension.

Weather Conditions

604. Paint shall not be applied when the air temperature is below 40°F, or when the air is misty, or when, in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work. It shall not be applied upon damp or frosted surfaces.

Material painted under cover in damp or cold weather shall remain under cover until dry or until weather conditions permit its exposure in the open. Painting shall not be done when the metal is hot enough to cause the paint to blister and produce a porous paint film.

Application

605. Painting shall be done in a neat and workmanlike manner. Brushes preferably shall be round or oval in shape, but if flat brushes are used they shall not exceed 4 inches in width.

The paint when applied shall be so manipulated under the brush as to produce a uniform, even coating in close contact with the metal or with previously applied paint and shall be worked into all corners and crevices.

On surfaces which are inaccessible to paint brushes, the paint shall be applied with sheepskin daubers specially constructed for the purpose.

Removal of Paint

606. If the painting is unsatisfactory to the Engineer, the paint shall be removed and the metal thoroughly cleaned and repainted.

Thinning Paint

607. If it is necessary in cool weather to thin the paint on account of congealing, this shall be done only by heating.

Cleaning

608. Surfaces of metal to be painted shall be thoroughly cleaned, removing rust, loose mill scale, dirt, oil or grease, and other foreign substances. The removal of rust, scale, and dirt shall be done by the use of metal brushes, scrapers, chisels, hammers, or other effective means. Oil and grease shall be removed by the use of gasoline or benzine. Bristle brushes shall be used for removing loose dust.

Contact and Inaccessible Surfaces

609. Surfaces to be riveted in contact either in the shop or field shall not be painted. Surfaces not in contact but which will be inaccessible after assembly or erection shall be painted two coats.

Shop Painting

610. When fabrication is complete and the work has been accepted, surfaces not painted before assembling, except surfaces to be in contact after erection, shall be painted one coat. Material shall not be loaded for shipment until the paint is dry.

Erection Marks

611. Erection marks shall be painted on painted surfaces.

Machine-Finished Surfaces

612. With the exception of abutting chord and column splices and column and truss shoe bases, machine-finished surfaces shall be coated as soon as practicable after being accepted, and before removal from the shop, with a hot mixture of white lead and tallow. Surfaces of iron and steel castings machine-finished for the sole purpose of removing scales, scabs, fins, blisters, or other surface deformations shall be given the shop coat of paint.

The composition used for coating machine-finished surfaces shall be mixed in the following proportions: 4 pounds tallow, 2 pounds white lead, and 1 quart linseed oil.

Section VII

WEIGHING, MARKING AND SHIPPING

Weighing of Members

701. Finished work shall be weighed in the presence of the Inspector, if practicable. The Contractor shall supply satisfactory scales and shall do the handling and weighing.

Marking and Shipping

702. Members weighing more than 3 tons shall have the weight marked thereon. Bolts and rivets of one length and diameter, and loose nuts or washers of each size, shall be packed separately. Pins, small parts, and small packages of bolts, rivets, washers, and nuts shall be shipped in boxes, crates, kegs, or barrels, but the gross weight of any package shall not exceed 300 lb. A list and description of the contained material shall be plainly marked on the outside of each package.

Anchor bolts, washers, and other anchorage or grillage materials, shall be shipped in time to suit the requirements of the masonry construction.

Handling Material

703. The loading, transportation, unloading, and storing of structural material shall be conducted so that the metal will be kept clean and free from injury.

Section VIII

ERECTION

Masonry

801. If the substructure and superstructure are built under separate contracts, the Purchaser will provide the masonry, constructed to correct lines and elevations and properly finished, and will establish the lines and elevations required for setting the steel.

Plans

802. If the fabrication and erection of the superstructure are done under separate contracts, the Purchaser will furnish detail plans for the bridge or bridges to be erected, including shop details, camber diagrams, erection diagrams, list of field rivets and bolts, and copy of shipping statements showing a list of parts and their weights.

Work to be Done

803. The Contractor shall erect the metal work, remove the temporary construction, and do all work required to complete the bridge or bridges as covered by the agreement, including the removal of the old structure or structures, if stipulated, all in accordance with the plans and these specifications.

Plant

804. The Contractor shall provide the falsework and all tools, machinery, and appliances, including drift pins and fitting up bolts, necessary for the expeditious handling of the work. Temporary structures or falsework placed by the Purchaser, if suitable, may be used by the Contractor.

Delivery of Materials

805. If the contract is for erection only, the Contractor shall receive the materials entering into the finished structure, free of charge at the place designated and loaded or unloaded as specified. The Contractor shall unload promptly upon delivery any material delivered on railroad cars which he is required to unload; otherwise he shall be responsible for demurrage charges.

Handling and Storing Materials

806. Material to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection. The Contractor shall check the material turned over to him against the shipping lists and report promptly in writing any shortage or injury discovered. He shall be responsible for the loss of any material while in his care, or for any damage resulting from his work.

Falsework

807. The falsework shall be properly designed and substantially constructed and maintained for the loads which will come upon it. The Contractor, if required, shall prepare and submit to the Engineer for approval, plans for falsework or for changes in an existing structure necessary for maintaining traffic. Approval of the Contractor's plans shall not be considered as relieving the Contractor of any responsibility.

Methods and Equipment

808. Before starting work, the Contractor shall inform the Engineer fully as to the method of erection he proposes to follow, and the amount and character of equipment he proposes to use, which shall be subject to

the approval of the Engineer. The approval of the Engineer shall not be considered as relieving the Contractor of the responsibility for the safety of his method or equipment or from carrying out the work in full accordance with the plans and specifications. No work shall be done without the sanction of the Engineer.

Bearings and Anchorage

809. Masonry bearing plates shall not be placed upon bridge-seat bearing areas which are improperly finished, deformed or irregular. Bearing plates shall be set level in exact position and shall have a full and even bearing upon the masonry. Unless otherwise directed by the Engineer, they shall be placed on a layer of canvas and red lead applied as follows:

Thoroughly swab the bridge seat bearing area with red lead paint and place upon it three layers of 12 to 14 ounce duck, each layer being thoroughly swabbed on its top surface with red lead paint. Place the superstructure shoes or pedestals in position while the paint is plastic.

The Contractor shall drill the holes and set the anchor bolts, except where the bolts are built into the masonry. The bolts shall be set accurately and fixed with Portland cement grout completely filling the holes. The location of the anchor bolts in relation to the slotted holes in the expansion shoes shall correspond with the temperature at the time of erection. The nuts on anchor bolts at the expansion ends of spans shall be adjusted to permit the free movement of the span.

Straightening Bent Material

810. The straightening of plates and angles or other shapes shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted by the Engineer, in which case the heating shall not be to a higher temperature than that producing a dark cherry red color. After heating the metal shall be cooled as slowly as possible.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.

Assembling Steel

811. The parts shall be accurately assembled as shown on the plans and any match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully riveted and all other truss connections pinned and bolted. Rivets in splices of butt joints of compression members and rivets in railings shall not be driven until the span has been swung. Splices and field connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before riveting. Splices and con-

nections carrying traffic during erection shall have three-fourths of the holes so filled.

Fitting up bolts shall be of the same nominal diameter as the rivets, and cylindrical erection pins shall be $\frac{1}{32}$ inch larger.

Riveting

812. Pneumatic hammers shall be used for field riveting, except when the use of hand tools is permitted by the Engineer. Rivets larger than ⅞ inch in diameter shall not be driven by hand. Cup-faced dollies, fitting the head closely to insure good bearing, shall be used. Connections shall be accurately and securely fitted up before the rivets are driven. Drifting shall be only such as to draw the parts into position and not sufficient to enlarge the holes or distort the metal. Unfair holes shall be reamed or drilled. Rivets shall be heated uniformly to a light cherry-red color and shall be driven while hot. They shall not be overheated or burned. Rivet heads shall be full and symmetrical, concentric with the shank, and shall have full bearing all around. They shall not be smaller than the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Caulking or recupping will not be permitted. In removing rivets, the surrounding metal shall not be injured; if necessary, they shall be drilled out.

Bolted Connections

813. In bolted connections, the bolts shall be drawn up tight and the threads burred at the face of the nut with a pointed tool.

Pin Connections

814. Pilot and driving nuts shall be used in driving pins. They will be furnished with the steel work and shall be returned to the Purchaser on completion of the work. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

Misfits

815. Corrections of minor misfits and a reasonable amount of reaming and cutting of excess stock from rivets will be considered a legitimate part of the erection. Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Inspector, and his approval of the method of correction obtained. The correction shall be made in the presence of the Inspector, who will check the time and material. The Contractor shall render within thirty days an itemized bill for such work of correction for the approval of the Engineer.

Removal of Old Structure and Falsework

816. If stipulated in the agreement, the Contractor shall dismantle the old structure which, unless otherwise provided, shall be the property of the

Purchaser, and shall dispose of it in the immediate vicinity of the bridge site as the Engineer may direct. If the old structure is to be re-erected, it shall be dismantled without unnecessary damage and the parts match-marked and carefully piled.

Upon completion and before final acceptance, the Contractor shall remove all falsework, excavated or useless materials, rubbish and temporary buildings, replace or renew any fences damaged and restore in an acceptable manner all property, both public and private, which may have been damaged during the prosecution of his work, and shall leave the bridge site and adjacent highways in a neat and presentable condition satisfactory to the Engineer. All excavated material or falsework placed in the stream channel during construction shall be removed by the Contractor before final acceptance.

Superintendence and Workmen

817. During the progress of the work the Contractor shall have a competent foreman or superintendent in personal charge of the work. Instructions given to the foreman or superintendent shall be considered as given to the Contractor. All work shall be done by skilled, competent workmen.

Responsibility

818. The Contractor shall be responsible for loss of, or damage to, materials; for all damage to persons or property; and for casualties of every description caused by his operations during the progress of the work.

Inspection

819. The work shall be subject at all times to inspection by the Engineer.

Laws and Permits

820. The Contractor shall comply with Federal, State and local laws, regulations, and ordinances, and shall obtain at his own expense the necessary permits for his operations.

Section IX

FIELD PAINTING

General Conditions

901. The requirements of Articles 601 to 608, inclusive, shall apply to field painting.

902. The Contractor shall protect pedestrian, vehicular and other traffic upon or underneath the bridge and also all portions of the bridge superstructure and substructure against damage or disfigurement by spatters, splashes and smirches of paint or paint materials.

Number of Coats and Color

903. Unless otherwise specified, field painting shall consist of two coats applied after erection.

The color of the paint shall be determined by the Engineer and the coats shall be sufficiently different in color to permit detection of incomplete application.

Field Painting

904. As soon as the field cleaning has been done to the satisfaction of the Inspector, the heads of field rivets and bolts, and any surfaces from which the shop coat of paint has been worn off or has become otherwise defective, shall be covered with one coat of the same paint as was used in the shop.

When the paint applied for touching up rivet heads and abraded surfaces has become dry, the first field coat may be applied. In no case shall a coat be applied until the previous coat has dried throughout the full thickness of the paint film.

To secure a maximum thickness of paint film on rivet heads and edges of plates, angles, and other rolled shapes, these parts shall be painted an extra coat in advance of the general application of each field coat.

Small cracks and cavities which have not been sealed in a watertight manner by the first field coat shall be filled with red lead paste before the second field coat is applied.

Section X

GENERAL FEATURES OF DESIGN

Materials

1001. Materials shall conform to the requirements specified in Section II. Except where otherwise provided, all members shall be of structural steel and rivets shall be of rivet steel.

Castings shall be steel or malleable castings, or cast iron. Cast iron shall be used only where specifically authorized by the Engineer.

Phosphor-bronze may be used in expansion bearings.

Width of Roadway and Sidewalk

1002. The width of roadway shall be the clear width measured at right angles to the longitudinal center line of the bridge between the tops of curbs or guard timbers. If there are no curbs or guard timbers, it shall be the clear width inside to inside of the handrails or other guards along the sides of the structure.

The width of the sidewalk shall be the clear width, measured at right angles to the longitudinal center line of the bridge, from the extreme inside portion of the handrail to the face of the curb or guard timber, except that if there is a truss, girder, or parapet wall adjacent to the roadway curb, the width shall be measured to its extreme outside portion.

Clearances

1003. The horizontal clearance shall be the clear width, and the vertical clearance the clear height, available for the passage of vehicular traffic, as shown on the clearance diagrams.

Unless otherwise provided the several parts of the structure shall be constructed to secure the following limiting dimensions or clearances for traffic.

The clearances and width of railway for two-lane traffic shall be not less than those shown in Fig. 1. The roadway width shall be increased at least 9 feet for each additional lane of traffic.

Bridges constructed for the combined use of highway and electric railway traffic shall have clearances not less than those shown in Fig. 2 and 3.

In cases involving curved tracks, the horizontal clearances shall be increased an amount corresponding to that required to maintain the specified clearances. If the outer rail is superelevated, the clearances shall be correspondingly increased.

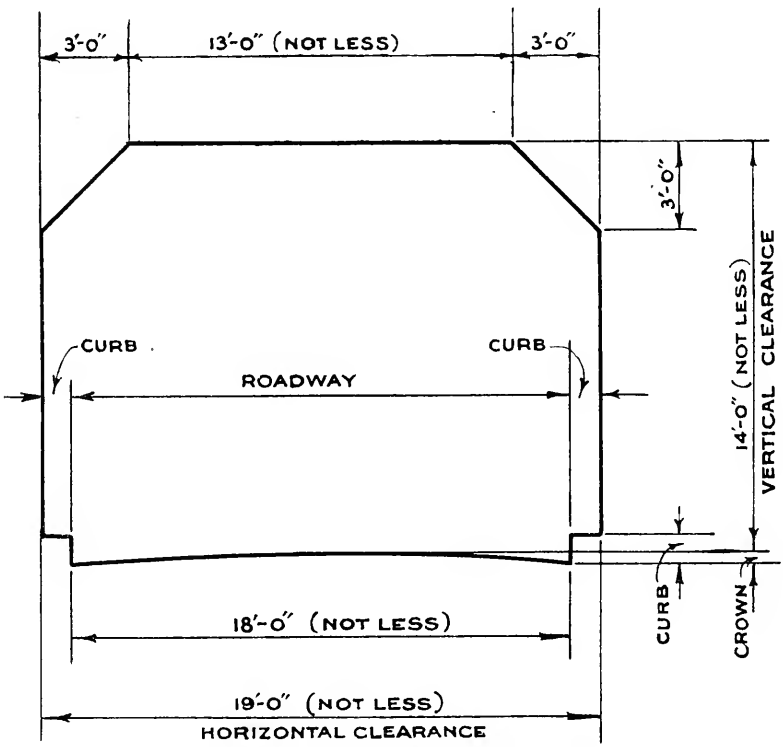


FIG. 1—CLEARANCE DIAGRAM TWO-LANE HIGHWAY TRAFFIC

Curbs

1004. The face of the curb shall be not less than 6 inches and preferably not less than 9 inches from that portion of the railing, truss, or girder nearest the roadway. The curb height shall be not less than

9 inches above the adjacent finished roadway surface, when not otherwise determined, or provided by law.

Concrete curbs shall be designed to resist a lateral force of not less than 500 lb. per linear foot of curb, applied at the top of the curb.

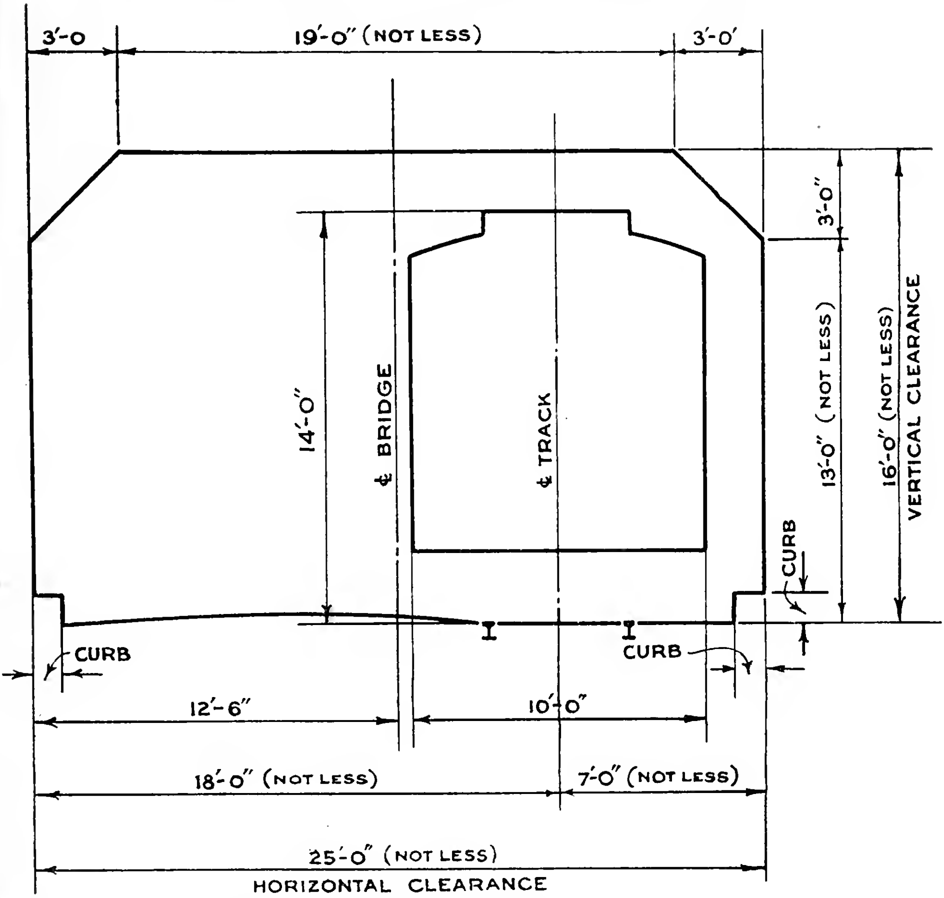


Fig. 2—Clearance Diagram Single Track Railway and One-Lane Highway Traffic

Railings

1005. Substantial railings along each side of the bridge shall be provided for the protection of traffic. The top of the railing shall be not less than 3 feet above the finished surface of the roadway adjacent to the curb, or if on a sidewalk, not less than 3 feet above the sidewalk floor.

Railings shall be designed to resist a horizontal force of not less than 150 lb. per linear foot, applied at the top of the railing, and a vertical force of not less than 100 lb. per linear foot.

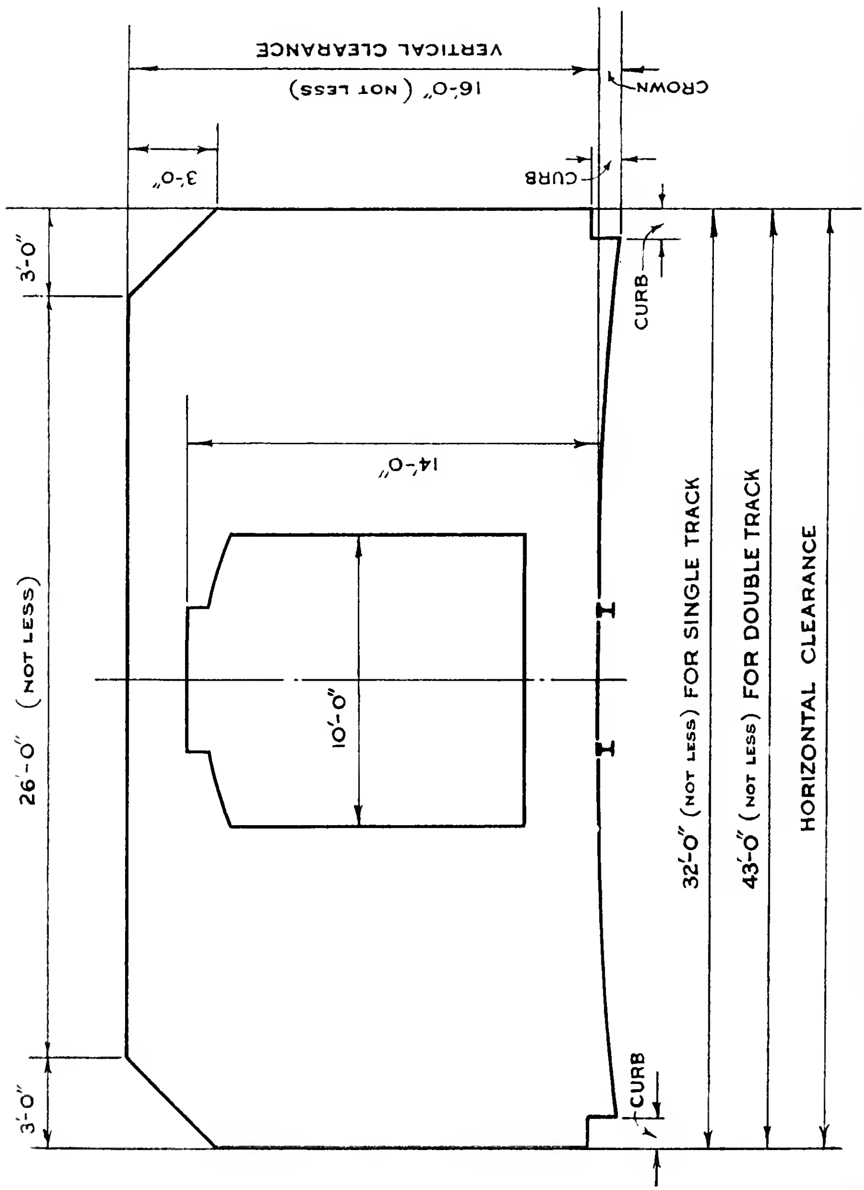


FIG. 3—CLEARANCE DIAGRAM ELECTRIC RAILWAY AND TWO-LANE HIGHWAY TRAFFIC

In general, railings shall be of two classes, as follows:

(1) Railings for the protection of pedestrians on bridges in cities and villages.

(2) Railings for use on country bridges not subject to general pedestrian traffic.

Metal railings of the first class shall consist of an upper and a lower horizontal rail connected by a suitable web. The clear distance between the top of the curb or the sidewalk and the lower rail shall not exceed 6 inches. Metal railings of the second class may consist of not less than two lines of horizontal rails of approved section. In each connection of the railing to the posts, truss members, etc., there shall be not less than two rivets or bolts. Provision shall be made for movement due to temperature.

Openings in concrete railings of the first class shall be proportioned with due regard to the safety of persons using the structure. Provision shall be made for the expansion and contraction of concrete railings at intervals consistent with the design.

Drainage

1006. The transverse drainage of roadways shall be secured by means of a suitable crown in the roadway surface. If necessary, longitudinal drainage shall be secured by means of scuppers, which shall be of sufficient size and number to drain the gutters adequately. If drainage gutters and downspouts are required, the downspouts shall be of cast or wrought iron pipe not less than 4 inches in diameter, provided with suitable clean-out fixtures. The details of floor drains shall be such as to prevent the discharge of drainage water against any portion of the structure. Overhanging portions of concrete and timber floors preferably shall be provided with drip beads.

Paved Floors

1007. Pavements other than wood block shall be supported by reinforced concrete slabs carried on steel or reinforced concrete floor members. Wood block pavements may be supported by a creosoted plank base.

Blast Protection

1008. On bridges over railroad tracks, metal likely to be injured by locomotive gases shall be protected by concrete. Concrete surfaces less than 20 feet above the tracks, shall be protected by cast iron blast plates located over the center line of each track. The plates shall be not less than 3 feet wide and not less than ¾ inch thick and so supported that they may be replaced readily. Pockets which will hold locomotive gases shall be avoided if practicable.

Utilities

1009. Where required, provisions shall be made for trolley wire supports and poles for lights, and suitable spaces shall be made available for electric conduits, water pipes and gas pipes.

Types of Bridges

1010. The different types of bridges may be used within the following limits, due consideration being given to transportation and erection conditions in selecting the type to be used.

Rolled beams for spans up to	60 feet
Plate girders for spans	30 to 125 feet
Riveted half-through trusses for spans	45 to 100 feet
Riveted trusses for spans above	90 feet
Pin-connected trusses for spans above	150 feet

Classification of Bridges

1011. The classification of bridges with reference to traffic shall be as follows:

Class AA. Bridges for specially heavy traffic units in locations where the passage of such loads is frequent.

Class A. Bridges for normally heavy traffic units and the occasional passage of specially heavy loads.

Class B. Bridges for light traffic units and the occasional passage of normally heavy loads. Class B bridges shall be considered as temporary or semi-temporary structures.

Class C. Bridges for electric railway traffic in addition to highway traffic. The latter may correspond to any one of the classes described above.

Section XI

LOADS

Loads

1101. Structures shall be proportioned for the following loads and forces:

(a) Dead Load.
(b) Live Load.
(c) Impact or dynamic effect of the live load.
(d) Lateral forces.
(e) Other forces, when they exist, as follows:
Longitudinal force; centrifugal force; and thermal forces.

Members shall be proportioned for the combination of loads and forces producing the maximum total stress, except as otherwise provided herein.

Upon the stress sheets a diagram of the assumed live loads shall be shown and the stresses due to the various loads shall be shown separately.

Dead Load

1102. The dead load shall consist of the weight of the structure complete, including the roadway, sidewalks, and car tracks, pipes, conduits, cables and other public utility services.

The snow and ice load is considered to be offset by an accompanying decrease in live load and impact and shall not be included except under special conditions.

In the case of structures having concrete slab floors, an adequate allowance shall be made in the design dead load to provide for the weight of a wearing surface. This allowance will depend upon the type of wearing surface contemplated; it shall be in addition to the weight of any monolithically placed concrete wearing surface; and shall be not less than 15 lb per square foot of roadway.

The following weights are to be used in computing the dead load:

	Weight per cubic foot, Pounds
Steel	490
Cast iron	450
Timber (treated or untreated)	60
Concrete, plain or reinforced	150
Loose sand and earth	100
Rammed sand or gravel, and ballast	120
Macadam or gravel, rolled	140
Cinder filling	60
Pavement, other than wood block	150
Railway rails and fastenings	150 lb. per linear foot of track

Live Load

1103. The live load shall consist of the weight of the applied moving load of vehicles, cars and pedestrians.

Highway Live Loads

1104. The highway live load on the roadway portion of the bridge shall consist of trains of motor trucks, or equivalent loads, as hereinafter specified. Each loading is designated by the letter H, followed by a numeral indicating the gross weight in tons of the heaviest loaded truck in the train.

Traffic Lanes

1105. The truck trains or equivalent loads shall be assumed to occupy traffic lanes, each having a width of 9 feet corresponding to the standard truck clearance width. Within the curb to curb width of the roadway, the traffic lanes shall be assumed to occupy any position which will produce the maximum stress, but which will not involve overlapping of adjacent lanes, nor place the center of the lane nearer than 4 feet 6 inches to the roadway face of the curb.

Trucks

1106. The wheel spacing, weight distribution, and clearance of the trucks used for design purposes shall be as shown in Fig. 4.

Highway Loading

1107. The highway loading shall be of three classes: namely, H20, H15, and H10, and may be either truck train loadings or equivalent loadings. Loadings H15 and H10 are 75 per cent and 50 per cent, respectively, of Loading H20.

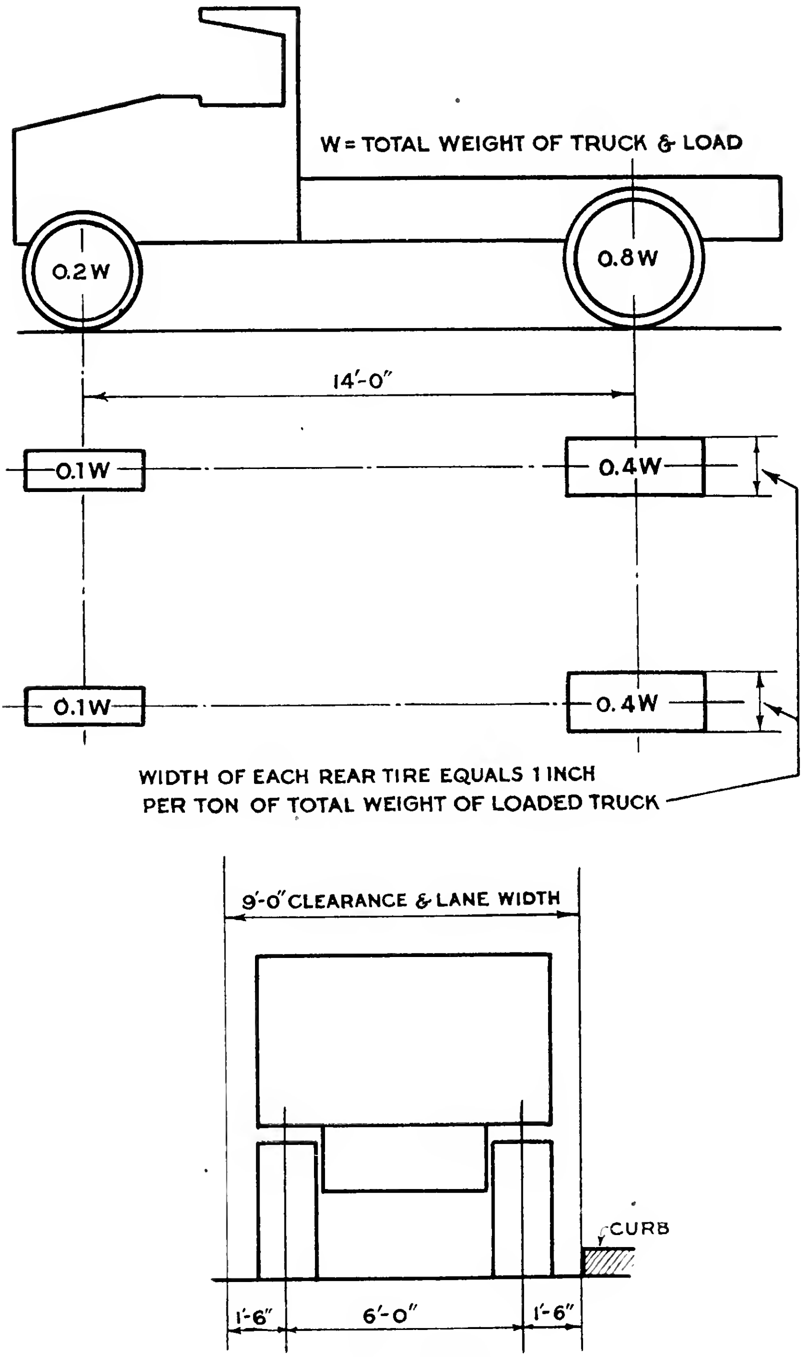

W = TOTAL WEIGHT OF TRUCK & LOAD
0.2 W
0.8 W
14'-0"
0.1 W
0.4 W
0.1 W
0.4 W
WIDTH OF EACH REAR TIRE EQUALS 1 INCH PER TON OF TOTAL WEIGHT OF LOADED TRUCK
9'-0" CLEARANCE & LANE WIDTH
CURB
1'-6"
6'-0"
1'-6"

Fig. 4—Truck

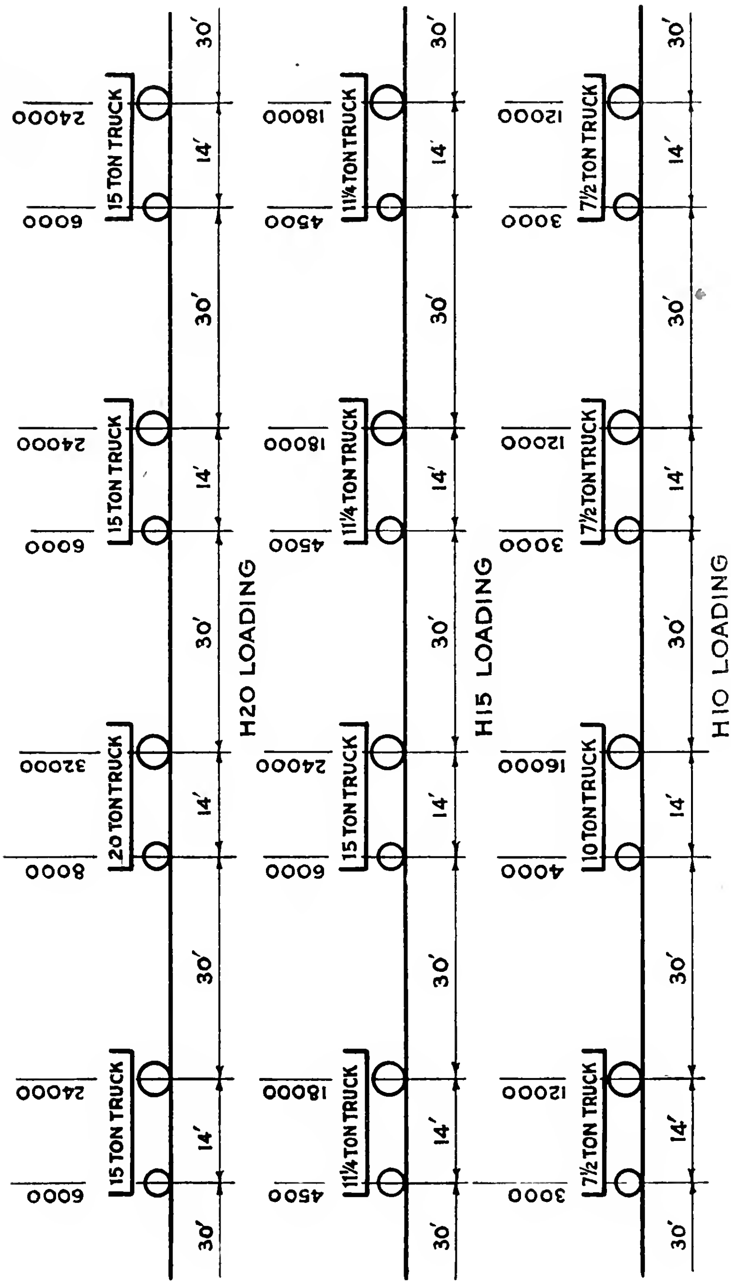


Fig. 5—Truck Train Loading

(a) Truck Train Loadings. The truck train loading shall be as shown in Fig. 5 and shall be used for loaded lengths of less than 60 feet. It shall consist of one truck of the gross weight indicated by the loading class followed by, or preceded by, or both followed and preceded by, a line of trucks of indefinite length, each of the following or preceding trucks having a gross weight of three-fourths of the gross weight indicated by the loading class.

Trucks in adjacent lanes shall be considered as headed in the same direction.

(b) Equivalent Loading. The equivalent loading shall be as shown in Fig. 6, and shall be used only for loaded lengths of 60 feet or greater. It shall consist of a uniform load per linear foot of traffic lane combined with a single concentrated load so placed on the span as to produce maximum stress. The concentrated load shall be considered as uniformly distributed across the lane on a line normal to the center line of the lane. For the computation of moments and shears, different concentrated loads shall be used as indicated in Fig. 6.

Selection of Loadings

1108. Bridges of the different classes shall be designed for the loadings as follows:

Class of Bridge	*Loading*
AA	H20
A	H15
B	H10

Application of Loadings

1109. The loadings shall be applied by that one of the following methods which produces the greater maximum stress in the member considered, allowance being made for the reduced load intensities hereinafter specified for roadways having loaded widths in excess of 18 ft.

(1) Each traffic lane loading shall be considered as a unit, and the number and position of the loaded lanes shall be such as will produce maximum stress.

(2) The roadway shall be considered as loaded over its entire width with a load per foot of width equal to one-ninth of the load of one traffic lane.

Reduction in Load Intensity

1110. If the loaded width of the roadway exceeds 18 feet, the specified loads shall be reduced one per cent for each foot of loaded roadway width in excess of 18 feet with a maximum reduction of twenty-five per cent, corresponding to a loaded roadway width of 43 feet. If the loads are lane loads, the loaded width of the roadway shall be the aggregate width of the lanes considered; if the loads are distributed over the entire width of the roadway, the loaded width of the roadway shall be the full width of roadway between curbs.

Electric Railway Loading

1111. If highway bridges carry electric railway traffic, the railway loading shall be determined on the basis of the class of traffic which the bridge may be expected to carry. The possibility that the bridge may be required to carry the freight cars of steam railroads shall be given consideration.

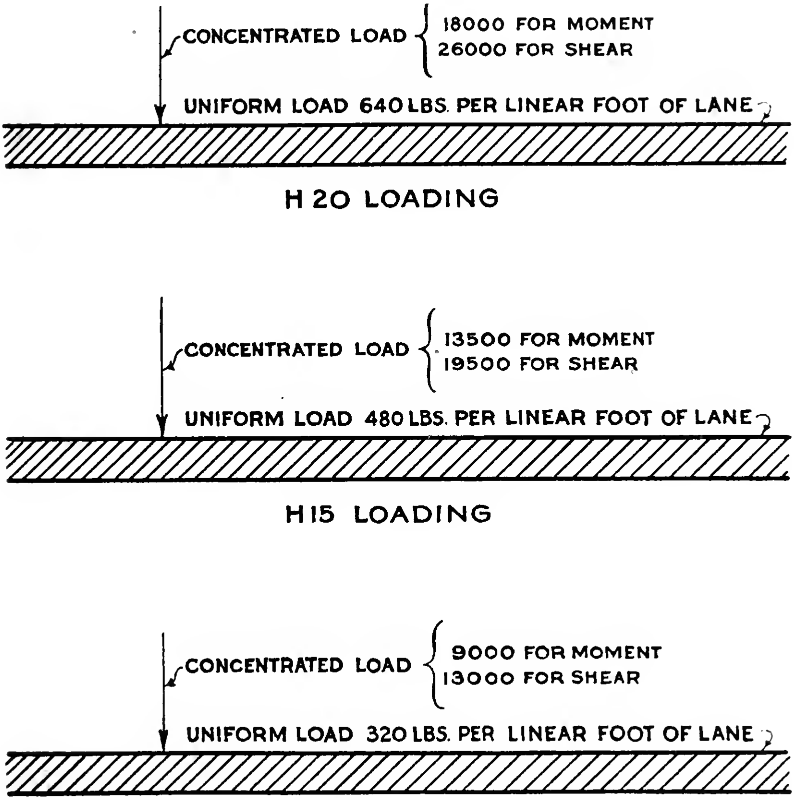


Fig. 6—Equivalent Loading

When not otherwise specified, the electric railway loading on each track shall be a train of two electric cars followed by, or preceded by, or both followed and preceded by, a uniform load. The cars shall be of one of the classes shown in Fig. 7. The class is designated by a numeral indicating the total loaded weight of each car. The uniform load per foot of track following or preceding electric cars shall be the uniform load corresponding to the class of highway loading specified (640 lb. per linear foot for H20 loading). The electric railway loading shall be assumed to occupy 10 feet of the roadway width.

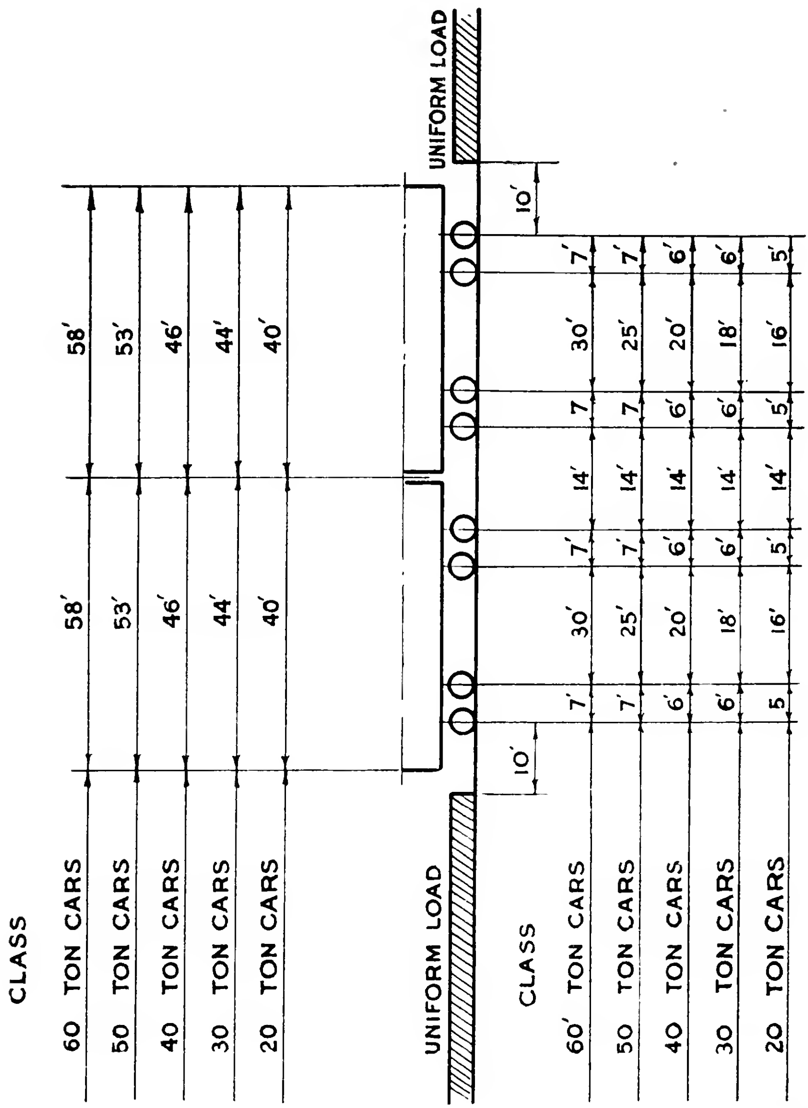


Fig. 7—Electric Railway Loading

For freight car loading, one of the classes of cars shown in Fig. 8 may be assumed in the absence of more exact data.

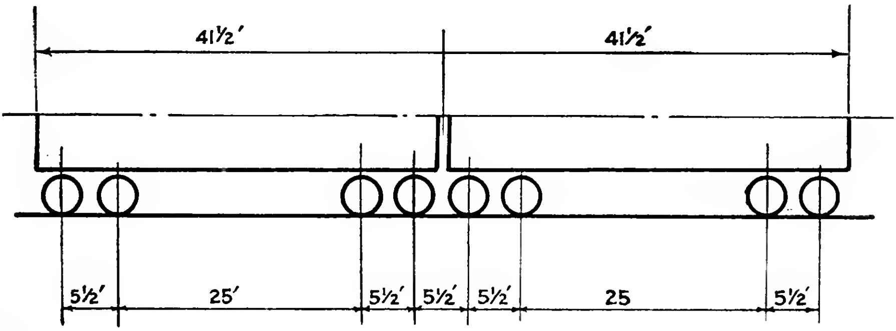
The railway loading used shall be shown on the stress sheets.

1112. Highway bridges carrying electric railway traffic shall be designed for the following loading conditions:

(1) The highway loading on any portion of the roadway area including that portion occupied by the railway.
(2) The electric railway loading on the car tracks and the highway loading on the remaining traffic lanes.

Sidewalk and Foot Bridge Loading

1113. Sidewalk floors, stringers, and their immediate supports shall be designed for a live load of not less than 100 lb. per square foot of sidewalk area.



TOTAL LOADED WEIGHT PER CAR
INCLUDING 10 PERCENT OVERLOAD
40 TON CAPACITY-132000 LBS.
70 TON CAPACITY-212000 LBS.

Fig. 8—Freight Car Loading

Girders or trusses of bridges with sidewalks shall be designed for a sidewalk live load determined by the following formula:

$$P = \left(40 + \frac{3000}{L}\right)\left(\frac{55 - W}{50}\right), \text{ in which:}$$

P = live load in lb. per square foot of sidewalk area, but not to exceed 100 lb. per square foot.
L = loaded length of sidewalk in feet.
W = width of sidewalk in feet.

In calculating stresses in structures which support cantilevered sidewalks, the sidewalk shall be considered as fully loaded on only one side of the structure if this condition produces maximum stress.

All parts of foot bridges shall be designed for a live load of not less than 100 pounds per square foot.

Impact

1114. Live load stresses, except those due to sidewalk loads and centrifugal, tractive, and wind forces, shall be increased by an allowance for dynamic, vibratory, and impact effects.

The amount of this allowance or increment is expressed as a fraction of the live load stress, and for both electric railway and highway loadings shall be determined by the formula:

$$I = \frac{50}{L + 125}, \text{ in which:}$$

I = impact fraction.
L = the length in feet of the portion of the span which is loaded to produce the maximum stress in the member considered.

Longitudinal Force

1115. Provision shall be made for the effect of a longitudinal force of 10 per cent of the live load on the structure, acting 4 feet above the floor.

Lateral Forces

1116. (a) The wind force on the structure shall be assumed as a moving horizontal load equal to 30 lb. per square foot on 1½ times the area of the structure as seen in elevation including the floor system and railings and on one-half the area of all trusses or girders in excess of two in the span.

(b) The lateral force due to the moving live load and the wind pressure against it, shall be considered as acting 6 feet above the roadway and shall be as follows:

Highway bridges, 200 lb. per linear foot.
Highway bridges carrying electric railway traffic, 300 lb. per linear foot.

(c) The total assumed wind force shall be not less than 300 lb. per linear foot in the plane of the loaded chord and 150 lb. per linear foot in the plane of the unloaded chord on truss spans, and not less than 300 lb. per linear foot on girder spans.

(d) In calculating the uplift, due to the foregoing lateral forces, in the posts and anchorages of viaduct towers, highway viaducts shall be considered as loaded on the leeward traffic lane with a uniform load of 400 lb. per linear foot of lane, and viaducts carrying electric railway traffic in addition to highway traffic shall be considered as loaded on the leeward track with a uniform load of 800 lb. per linear foot of track.

(e) A wind pressure of 50 lb. per square foot on the unloaded structure, applied as specified above in paragraph (a), shall be used if it produces greater stresses than the combined wind and lateral forces of paragraphs (a) and (b).

Centrifugal Force

1117. If the electric railway track is curved, the structure shall be designed to resist a lateral force equal to 10 per cent of the moving railway loading. This lateral force shall be considered as acting 4 feet above the top of rail.

Thermal Forces

1118. In fixed arched spans, provision shall be made for the stresses resulting from the following variations in temperature:

Moderate climate, from 0 degrees to 120 degrees Fahr.
Cold climate, from —30 degrees to 120 degrees Fahr.

The rise and fall in temperature shall be figured from an assumed temperature at the time of erection.

Section XII

DISTRIBUTION OF LOADS

Distribution of Wheel Loads to Stringers and Floorbeams

1201. Shear.—In calculating end shears and end reactions in transverse floorbeams and longitudinal beams and stringers, no lateral or longitudinal distribution of the wheel load shall be assumed.

Bending Moment in Stringers.—In calculating bending moments in longitudinal beams or stringers, no longitudinal distribution of the wheel loads shall be assumed. The lateral distribution shall be determined as follows:

(a) Interior Stringers.

Interior stringers shall be proportioned for loads determined in accordance with the following table, except that when the limiting stringer spacings are exceeded, the stringer loads shall be determined by the reactions of the truck wheels, assuming the flooring between stringers to act as a simple beam.

KIND OF FLOOR	Floor designed for one traffic lane		Floor designed for two or more traffic lanes	
	Fraction of a wheel load to each stringer	Limiting stringer spacing in feet	Fraction of a wheel load to each stringer	Limiting stringer spacing in feet
Plank	$\frac{S}{4.0}$	4.0	$\frac{S}{3.5}$	5.0
Strip 4 in. in thickness or wood block on 4 in. plank sub-floor	$\frac{S}{4.5}$	4.5	$\frac{S}{3.75}$	5.5
Strip 6 in. or more in thickness	$\frac{S}{5.0}$	5.0	$\frac{S}{4.0}$	6.0
Concrete	$\frac{S}{6.0}$	6.0	$\frac{S}{4.5}$	10.0

S = spacing of stringers in feet

A

(b) Outside Stringers.

The live load supported by outside stringers shall be the reaction of the truck wheels, assuming the flooring to act as a simple beam between stringers.

(c) Total Capacity of Stringers.

The combined load capacity of the beams in a panel shall not be less than the total live and dead load in the panel.

Bending Moment in Floorbeams.—In calculating bending moments in floorbeams, no transverse distribution of the wheel loads shall be assumed.

If longitudinal stringers are omitted and the floor is supported directly on the floorbeams, the latter shall be proportioned for a fraction of the wheel loads as indicated in the following table, except that when the limiting floor beam spacing is exceeded the floor beam loads shall be determined by the reactions of the truck wheels, assuming the flooring between floor beams to act as a simple beam.

KIND OF FLOOR	Fraction of wheel loads to each floorbeam	Limiting floor-beam spacing in feet
Plank	$\frac{S}{4.0}$	4.0
Strip 4 in. in thickness or wood block on 4 in. plank sub-floor	$\frac{S}{4.5}$	4.5
Strip 6 in. or more in thickness	$\frac{S}{5.0}$	5.0
Concrete	$\frac{S}{6.0}$	6.0

S = spacing of floor beams in feet.

Distribution of Wheel Loads on Concrete Slabs

1202. Bending Moment.—In calculating bending stresses due to wheel loads on concrete slabs, no distribution in the direction of the span of the slab shall be assumed. In the direction perpendicular to the span of the slab, the wheel load shall be considered as distributed uniformly over a width of slab which is termed the "effective width" and is obtained from the following formulas in which:

S = span of slab in feet.
W = width of wheel or tire in feet.
D = distance in feet from the center of the near support to the center of wheel.
E = effective width in feet for one wheel.

Case I. Main Reinforcement Parallel to Direction of Traffic.

$E = 0.7\,S + W$, in which E shall have a maximum value of 7.0 feet.

When two wheels are so located on a transverse element of the slab that their effective widths overlap, the effective width for each wheel shall be $\frac{1}{2}(E + C)$, in which E is the value determined by the formula above and C is the distance between centers of wheels.

Case II. Main Reinforcement Perpendicular to Direction of Traffic.
$E = 0.7\ (2D + W)$.

For this case the bending moment on a strip of slab one foot in width shall be determined by placing the wheel loads in the position to produce the maximum bending, assuming no distribution; determining the effective width for each wheel; and assuming the load of each wheel on the one-foot strip to be the wheel load divided by its respective effective width.

The design assumption of Case II does not provide for the effect of loads near unsupported edges. Therefore, at the ends of the bridge and at intermediate points where the continuity of the slab is broken, the edges of the slab shall be supported by diaphragms or other suitable means.

Shear.—Slabs designed for bending moment in accordance with the foregoing rules and for the wheel loads contemplated by these specifications may be considered adequate for shear without special reinforcement.

Distribution of Electric Railway Wheel Loads

1203. Electric railway wheel loads shall be assumed to be uniformly distributed longitudinally over a length of 3 feet. In the case of ballasted floors, a lateral distribution of 10 feet for an axle load shall be assumed.

Section XIII

UNIT STRESSES

General

1301. Except as modified elsewhere in these specifications the several parts of a structure shall be so proportioned that the unit stresses will not exceed those specified below.

Members of structural steel shall be so proportioned that an increase of the highway live load by 100 per cent or the electric railway live load by 50 per cent will not produce combined unit stresses in the members more than those specified for dead load.

Unless otherwise noted, unit stresses are given in pounds per square inch.

Structural Grade and Rivet Steel

1302. For structural grade and rivet steel:

Tension

	For Live Load and Lateral Forces	*For Dead Load*
Axial tension, structural members, but not to exceed the value for	16,000	24,000
Bolts, area at root of thread.....	10,000	15,000

Axial Compression		
Axial compression, gross section..	$\dfrac{16{,}000}{1+\dfrac{1}{13{,}500}(l/r)^2}$	$\dfrac{24{,}000}{1+\dfrac{1}{13{,}500}(l/r)^2}$
but not to exceed the value for $l/r = 40$		
l = length of the member, in inches.		
r = least radius of gyration of the member, in inches.		
Compression splice material, gross section	16,000	24,000
Bending on Extreme Fiber		
Compression in flanges of beams and plate girders............	$\dfrac{16{,}000}{1+\dfrac{1}{2{,}000}(l/b)^2}$	$\dfrac{24{,}000}{1+\dfrac{1}{2{,}000}(l/b)^2}$
l = length in inches of the unsupported flange between lateral connections or knee braces.		
b = flange width, in inches.		
Tension in rolled shapes, built sections and girders net section..	16,000	24,000
Pins	24,000	36,000
Diagonal Tension		
In webs of girders and rolled beams, at sections where maximum shear and bending occur simultaneously	16,000	24,000
Shear		
Girder webs, gross section.......	10,000	15,000
Pins and shop driven rivets......	12,000	18,000
Power driven field rivets and turned bolts	10,000	15,000
Hand driven rivets and unfinished bolts	8,000	12,000
Bearing		
Pins, steel parts in contact and shop driven rivets...........	24,000	36,000
Power driven field rivets and turned bolts	20,000	30,000
Hand driven rivets and unfinished bolts	16,000	24,000
Expansion rollers, pounds per linear inch	600 d	900 d
d = diameter of roller in inches.		

In proportioning rivets, the nominal diameter shall be used.

The effective bearing area of a pin, a bolt, or a rivet shall be its diameter multiplied by the thickness of the metal on which it bears.

In metal ⅜ inch thick and over, half the depth of countersink shall be omitted in calculating bearing area. In metal less than ⅜ inch thick, countersunk rivets shall not be assumed to carry stress.

Steel Castings

1303. For steel castings, three-fourths of the unit stresses specified above for structural grade steel shall apply.

Cast Iron

1304. For cast iron:

Bending on extreme fiber	3,000
Shear	3,000
Direct compression (short columns)	12,000

Bronze

1305. Bearing on bronze expansion bearings 2,000

Bearing on Masonry

1306.	Bearing on granite masonry	800
	Bearing on sandstone and limestone masonry	400
	Bearing on concrete masonry	600

Section XIV

PROPORTIONING OF PARTS

Ambiguity of Stress

1401. Structures shall be so designed as to avoid, as far as practicable, ambiguity in the determination of the stresses.

Number of Trusses or Girders

1402. Preferably through spans shall have only two trusses or girders.

Spacing of Trusses and Girders

1403. Main trusses and girders shall be spaced a sufficient distance apart center to center, to be secure against overturning by the assumed lateral forces.

Effective Span

1404. For the calculation of stresses, span lengths shall be assumed as follows:

Beams and girders, distance between centers of bearings.
Trusses, distance between centers of end pins or of bearings.
Floor beams, distance between centers of trusses or girders.
Stringers, distance between centers of floor beams.

Effective Depth

1405. For the calculation of stresses, effective depths shall be assumed as follows:

Riveted trusses, distance between centers of gravity of the chords.
Pin-connected trusses, distance between centers of chord pins.
Plate girders, distance between centers of gravity of the flanges, but not to exceed the distance back to back of flange angles.

Alternate Stresses

1406. Members subject to alternate stresses of tension and compression, due to the combination of dead, live, impact and centrifugal stresses, shall be proportioned for the kind of stress requiring the larger section.

If the alternate stresses occur in succession during one passage of the live load, each shall be increased by 50 per cent of the smaller. The connections of such members shall be proportioned for the sum of the net alternate stresses not so increased.

If the live load and dead load stresses are of opposite sign, only 70 per cent of the dead load stress shall be considered as effective in counteracting the live load stress.

Combined Stresses

1407. Members subject to both axial and bending stresses shall be proportioned so that the combined fiber stresses will not exceed the specified axial unit stress. If members are continuous over panel points, three-fourths of the bending stress, computed as for a simple beam, shall be added to the axial stress.

Secondary Stresses

1408. Designing and detailing shall be done so as to avoid secondary stresses as far as practicable. In ordinary trusses without sub-paneling, no account usually need be taken of the secondary stresses in any member whose width measured in the plane of the truss is less than one-tenth of the length of the member. If the width is greater than one-tenth of the length, or if sub-paneling is used, secondary stresses due to deflection of the truss shall be considered.

Rolled Beams

1409. Rolled beams shall be proportioned by the moments of inertia of their net sections.

Limiting Lengths of Members

1410. For compression members, the ratio of unsupported length to the least radius of gyration shall not exceed 120 for main and stiffening members nor 140 for laterals and sway bracing. In proportioning the top chords of half-through trusses, the unsupported length shall be assumed as the length between laterally supported panel points.

For main riveted tension members, the ratio of length to least radius of gyration shall not exceed 200.

Depth Ratios

1411. The ratio of the depth to the length of spans preferably shall be not less than the following:

For trusses ....one-tenth
For plate girders................................one-fifteenth
For rolled beams used as girders.................one-twentieth

If depths less than these are used, the sections shall be so increased that the maximum deflection will not be greater than if these ratios had not been exceeded.

Symmetrical Sections

1412. Main members shall be proportioned so that their gravity axes will be as nearly as practicable in the center of the section.

Effective Area of Angles in Tension

1413. The effective area of a single angle tension member, or of each angle of a double angle tension member in which the angles are connected back to back on the same side of a gusset plate, shall be assumed as the net area of the connected leg plus half of the area of the unconnected leg.

If a double angle tension member is connected with the angles back to back on opposite sides of a gusset plate, the full net area of the angles shall be considered as effective. If the angles connect to separate gusset plates, as in the case of a double-webbed truss, and the angles are connected by stay plates located as near the gussets as practicable, or by other effective means, the full net area of the angles shall be considered as effective. If the angles are not so connected, only 80 per cent of the net area shall be considered as effective.

Lug angles shall not be considered as effective in transmitting stress.

Minimum Thickness of Metal

1414. Gusset plates shall be not less than $\frac{3}{8}$ inch in thickness. Other structural steel, except for fillers and in railings, shall be not less than $\frac{5}{16}$ inch in thickness.

Metal subjected to marked corrosive influence shall be increased in thickness or specially protected against corrosion.

Plates in Compression

1415. The thickness of web plates of compression members shall be not less than one-thirtieth of the transverse distance between the lines of rivets connecting them to the flanges. The thickness of cover plates of compression members and cover plates on the compression flanges of plate girders preferably shall be not less than one-fortieth of the transverse distance between the lines of rivets connecting them to the flanges, but the minimum may be one-fiftieth of this distance, provided that the width of the plate between the connecting lines of rivets in excess of 40 times the thickness shall not be considered as effective in resisting stress.

Outstanding Legs of Angles

1416. The widths of the outstanding legs of angles in compression (except where reinforced by plates) shall not exceed the following:

In girder flanges, twelve times the thickness.
In main members carrying axial stress, twelve times the thickness.
In bracing and other secondary members, sixteen times the thickness.

Size of Pins

1417. Pins shall be proportioned for the maximum shears and bending moments produced by the stresses in the members connected. If there are eyebars among the parts connected, the diameter of the pin shall be not less than three-fourths of the width of the widest bar.

Section XV

GENERAL DETAILS OF DESIGN

Size of Rivets

1501. Rivets shall be of the size shown on the drawings but generally shall be ¾ inch or ⅞ inch in diameter. Rivets ⅝ inch in diameter shall not be used in members carrying calculated stress except in 2½ inch legs of angles and in flanges of 6-inch and 7-inch beams and channels.

The diameter of rivets in angles carrying calculated stress shall not exceed one-fourth of the width of the leg in which they are driven. In angles whose size is not determined by calculated stress, ⅝-inch rivets may be used in 2-inch legs, ¾-inch rivets in 2½-inch legs, ⅞-inch rivets in 3-inch legs, and 1-inch rivets in 3½-inch legs.

Structural shapes which do not admit the use of ⅝-inch diameter rivets shall not be used except in hand rails.

Pitch of Rivets

1502. The minimum distance between centers of rivets shall be three times the diameter of the rivet but preferably shall be not less than the following:

For 1-inch rivets, 3½ inches.
For ⅞-inch rivets, 3 inches.
For ¾-inch rivets, 2½ inches.
For ⅝-inch rivets, 2¼ inches.

Pitch in Ends of Compression Members

1503. In the ends of compression members the pitch of rivets connecting the component parts of the member shall not exceed four times the diameter of the rivet for a length equal to 1½ times the maximum width of the member. Beyond this point the pitch shall be increased gradually for a length equal to 1½ times the maximum width of the member until the maximum pitch is reached.

Maximum Pitch

1504. The maximum pitch in the line of stress shall not exceed 6 inches or 16 times the thickness of the thinnest outside plate or angle connected, except that in angles having two gage lines with the rivets staggered, the pitch in each line may be twice that given by these rules, with a maximum of 10 inches.

Stitch Rivets

1505. If two or more web plates are in contact, they shall be held together by stitch rivets. In compression members, the stitch rivets shall be spaced, in the direction perpendicular to the line of stress, not more than 24 times the thickness of the thinnest plate, and, in the line of stress, not more than 12 times the thickness of the thinnest plate. In tension members and girders, the stitch rivets shall be spaced, in either direction, not more than 24 times the thickness of the thinnest outer plate. In tension members composed of two angles in contact, the angles shall be held together by stitch rivets having a maximum pitch of 12 inches.

Edge Distance of Rivets

1506. The minimum distance from the center of any rivet to a sheared edge shall be:

For 1-inch rivets, 1¾ inches.
For ⅞-inch rivets, 1½ inches.
For ¾-inch rivets, 1¼ inches.
For ⅝-inch rivets, 1⅛ inches.

The minimum distance from a rolled or planed edge, except in flanges of beams and channels, shall be:

For 1-inch rivets, 1½ inches.
For ⅞-inch rivets, 1¼ inches.
For ¾-inch rivets, 1⅛ inches.
For ⅝-inch rivets, 1 inch.

The maximum distance from any edge shall be eight times the thickness of the thinnest outside plate, but shall not exceed 5 inches.

Long Rivets

1507. Rivets subjected to calculated stress and having a grip in excess of 4½ diameters shall be increased in number at least one per cent for each additional $\frac{1}{16}$ inch of grip. If the grip exceeds 6 times the diameter of the rivet, specially designed rivets shall be used.

Rivets in Tension

1508. Rivets in direct tension shall, in general, not be used, but if so used their value shall be one-half that permitted for rivets in shear. Countersunk rivets shall not be used in tension.

Parts Accessible

1509. The accessibility of all parts of a structure for inspection, cleaning, and painting shall be secured by the proper proportioning of members and the design of their details.

Closed Sections and Pockets

1510. Closed sections, and pockets or depressions which will retain water shall be avoided so far as practicable. Pockets shall be provided with effective drain holes or be filled with waterproof material.

Details shall be so arranged that the retention of dirt, leaves, and other foreign matter will be reduced to a minimum. Wherever angles are used, either singly or in pairs, preferably they shall be placed with the vertical legs extending downward.

Eccentric Connections

1511. Members, including bracing, shall be so connected that their gravity axes will intersect in a point. Eccentric connections shall be avoided if practicable, but if unavoidable the members shall be so proportioned that the combined fiber stresses will not exceed the allowed axial stress.

Strength of Connections

1512. Unless otherwise provided, connections shall be proportioned to develop the full strength of the members connected.

Connections shall be made symmetrical about the axes of the members in so far as practicable. Connections, except for lacing bars and hand rails, shall contain not less than three rivets.

Splices

1513. Continuous compression members, such as chords and trestle posts, in riveted structures shall have milled ends and full contact bearing at the splices.

Splices, whether in tension or compression, shall be proportioned to develop the full strength of the members spliced and no allowance shall be made for the bearing of milled ends of compression members.

Splices shall be located as close to panel points as possible and, usually, shall be on that side of the panel point where the smaller stress occurs.

The arrangement of the plates, angles and other splice elements shall be such as to make proper provision for the stresses, both axial and bending, in the component parts of the members spliced.

Indirect Splices

1514. If splice plates are not in direct contact with the parts which they connect, the number of rivets on each side of the joint shall be in excess of the number required for a direct-contact splice to the extent of two extra transverse lines of rivets for each intervening plate.

Fillers

1515. If rivets carrying stress pass through fillers, the fillers shall be extended beyond the connected member and the extension secured by enough additional rivets to carry the stress passing through the fillers. If the filler is less than ¼ inch thick it shall not be extended beyond the splicing material.

Gusset Plates

1516. Gusset or connecting plates shall be used for connecting main members, except when they are pin-connected. The rivets connecting each member shall be symmetrical with the axis of the member, so far as practicable, and the full development of the elements of the member shall be given consideration. The gusset plates shall be of ample thickness to resist shear, direct stress, and flexure, acting on the weakest or critical section of maximum stress.

Reentrant cuts shall be avoided as far as practicable.

Stay Plates

1517. The open sides of compression members shall be provided with lacing bars and shall have stay plates as near each end as practicable. Stay plates shall be provided at intermediate points where the lacing is interrupted. In main members, the length of the end stay plates between end rivets shall be not less than 1¼ times the distance between the inner lines of rivets connecting them to the flanges; and the length of intermediate stay plates between end rivets, not less than three-fourths of that distance. In lateral struts and other secondary members, the over-all length of end and intermediate stay plates shall be not less than three-fourths of the distance between the inner lines of rivets connecting them to the flanges.

The separate segments of tension members composed of shapes may be connected by stay plates or end stay plates and lacing. End stay plates shall have the same minimum length as specified for end stay plates on main compression members and intermediate stay plates shall have a minimum length of three-fourths of that specified for intermediate stay plates on main compression members. The clear distance between stay plates on tension members shall not exceed 3 feet.

The thickness of stay plates shall be not less than one-fiftieth of the distance between the inner rivet lines connecting them to the flanges. Stay plates shall be connected by not less than three rivets on each side and in members having lacing bars, the last rivet in the stay plate preferably shall also pass through the end of the adjacent bar.

Lacing Bars

1518. The lacing of compression members shall be proportioned to resist shearing stresses normal to the member not less than those determined by the formulas:

$$(1) \quad R = \frac{4I}{CL}(24{,}000 - p)$$

$$(2) \quad R = \frac{0.4pI}{CL}$$

in which

R = normal shearing stress in pounds.
I = moment of inertia of section about an axis perpendicular to the plane of the lacing.
C = distance from neutral axis to extreme fiber, in inches.
L = length of member, in inches.
p = average compressive unit stress in the member; $= \frac{P}{A}$
P = total stress in the member including the increases in live load, specified in Article 1301.
A = gross section of the member, in square inches.

The greater of the values given by these two formulas shall be used.

If the lacing of a horizontal or inclined compression member is in a vertical plane, the shear in the lacing caused by the weight of the member shall be added to the shear calculated by the formulas above.

The shear shall be considered as divided equally among all shear resisting elements in parallel planes, whether made up of continuous plates or of lacing. The size of the bar shall be determined by the formula for axial compression in Section XIII in which L shall be taken as the distance between the connections to the main sections.

The minimum width of lacing bars shall be:

For 1-inch rivets, 2¾ inches.
For ⅞-inch rivets, 2½ inches.
For ¾-inch rivets, 2¼ inches.
For ⅝-inch rivets, 2 inches.

The minimum thickness of bars shall be one-fortieth of the distance between connections for single lacing, and one-sixtieth for double lacing, but not less than five-sixteenths inch.

Lacing bars of compression members shall be so spaced that the L/r of the portion of the flange included between lacing bar connections will be not greater than 40, and not greater than two-thirds of the L/r of the member.

The angle between the lacing bars and the axis of the member shall be approximately 45 degrees for double lacing and 60 degrees for single lacing. If the distance between rivet lines in the flanges is more than 15 inches, and a bar with a single rivet in the connection is used, the lacing shall be double and riveted at the intersections. Lacing bars having at least two rivets in each end shall be used on flanges 5 inches or more in width.

Shapes of equal strength may be used instead of flats.

Net Section at Pin Holes

1519. In pin-connected riveted tension members, the net section across the pin hole shall be not less than 140 per cent and the net section back of the pin hole not less than 100 per cent of the net section of the body of the member.

Net Section of Riveted Tension Members

1520. In calculating the required section of riveted tension members, net sections shall be used in all cases and, in deducting rivet holes, the holes shall be taken as ⅛ inch larger than the nominal diameter of the rivet.

The net section shall be the least area which can be obtained by deducting from the gross sectional area, the area of holes cut by any straight or zigzag section across the member, counting the full area of the first hole and a fractional part of each succeeding hole, the fractional part being determined by the formula:

$$X = 1 - \frac{S^2}{4gh}, \text{ in which}$$

X = fraction of rivet hole to be deducted.
S = stagger or longitudinal spacing of rivet with respect to rivet on last gage line.
g = distance between gage lines, or transverse spacing.
h = diameter of rivet holes, or nominal diameter of rivet plus ⅛ inch.

Location of Pins

1521. Pins shall be so located with respect to the gravity axes of the members, as to reduce secondary stresses due to bending to a minimum.

Pin Plates

1522. Where necessary to give the required section or bearing area at pin holes, each segment of the member shall be reinforced by plates. One plate on each side shall be as wide as the outstanding flanges will permit. In the case of members composed of web plates and flange angles (with or without a cover plate) there shall be at least one pin plate covering the vertical legs of the flange angles. Pin plates shall contain enough rivets and be so connected as to transmit and distribute the bearing pressure uniformly over the full cross section and to reduce the eccentricity in the segment to a minimum.

Pin-connected compression members shall be provided with hinge plates not less than 3/8 inch thick.

Forked Ends

1523. Forked ends on compression members will be permitted only where unavoidable. If forked ends are used, pin plates shall be provided to make the total sectional area of the jaws equal to twice the sectional area of the member. These plates shall be extended as far as necessary to carry the stress of the main member into the jaws.

Pins and Pin Nuts

1524. Pins shall be of sufficient length to secure a full bearing of all parts connected upon the turned body of the pin. They shall be secured in position by hexagonal chambered nuts or by hexagonal solid nuts with washers. If the pins are bored, through rods with cap washers may be used. Pin nuts shall be malleable castings or steel. They shall be secured by cotter pins in the screw ends or else the screw ends shall be long enough to permit burring the threads.

Members shall be held against lateral movement on the pins.

Bolts

1525. Bolted connections shall not be used unless specifically authorized. Bolts shall be unfinished or turned as specified and shall meet the requirements of Article 319. Bolts in tension shall have two nuts.

Upset Ends

1526. Bars and rods with screw ends shall be upset to provide a section at the root of the thread which will exceed the net section of the body of the member by at least 15 per cent.

Sleeve Nuts

1527. Sleeve nuts shall not be used.

Expansion

1528. Provision shall be made for expansion and contraction at the rate of 1¼ inches for every 100 feet. The expansion ends shall be secured against lateral movement.

Expansion Bearings

1529. Spans of less than 70 feet may be arranged to slide upon metal plates with smooth surfaces. Spans of 70 feet and greater shall be provided with rollers or rockers, or else with bronze sliding expansion bearings.

Bronze Sliding Expansion Bearings

1530. Bronze sliding plates shall be chamfered at the ends. They shall be held securely in position, usually by being inset into the metal of the pedestals and sole plates. Provision shall be made against any accumulation of dirt which will obstruct free movement of the span.

Fixed Bearings

1531. Fixed ends shall be firmly anchored.

Pedestals and Shoes

1532. Pedestals and shoes preferably shall be made of cast steel or structural steel. The difference in width between the top and bottom bearing surfaces shall not exceed twice the distance between them. For hinged bearings, this distance shall be measured from the center of the pin. In built pedestals and shoes, the web plates and angles connecting them to the base plate shall be not less than ⅝ inch thick. If the size of the pedestal permits, the webs shall be rigidly connected transversely. The minimum thickness of the metal in cast steel pedestals shall be one inch. Pedestals and shoes shall be so designed that the load will be distributed uniformly over the entire bearing. Spans of 70 feet and greater shall have hinged or pin bearings at both ends.

Rollers

1533. Expansion rollers shall be not less than 6 inches in diameter. They shall be connected by substantial side bars and shall be guided by gearing or other effectual means to prevent lateral movement, skewing and creeping. The rollers and bearing plates shall be protected from dirt and water as far as practicable, and the design shall be such that water will not be retained and that the roller nests may be inspected and cleaned easily.

Inclined Bearings

1534. For spans on an inclined grade and without hinged bearings, the sole plates shall be beveled so that the masonry surfaces and the sliding surfaces will be level.

Anchor Bolts

1535. Trusses, girders and I-beam spans shall be securely anchored to the substructure. Anchor bolts shall be swedged or threaded to secure a satisfactory grip upon the material used to embed them in the holes.

The following are the minimum requirements for each bearing:

For I-beam spans the outer beams shall be anchored at each end with two bolts 1-inch in diameter, set 10 inches in the masonry.

For trusses and girders:

Spans 50 feet in length or less, 2 bolts, 1-inch in diameter, set 10 inches in the masonry.

Spans 51 to 100 feet, 2 bolts, 1¼ inches in diameter, set 12 inches in the masonry.

Spans 101 to 150 feet, 2 bolts, 1½ inches in diameter, set 15 inches in the masonry.

Spans greater than 150 feet, 4 bolts, 1½ inches in diameter, set 15 inches in the masonry.

Anchor bolts subject to tension shall be designed to engage a mass of masonry which will provide a resistance equal to 1½ times the calculated uplift.

Name Plates

1536. Unless otherwise specified there shall be a name plate, showing in raised letters and figures the name of the manufacturer and the year of construction, bolted to the bridge near each end at a point convenient for inspection.

Section XVI

FLOOR SYSTEM

Stiffness of Floor Members

1601. Floor members shall be designed with special reference to stiffness by making them as deep as economy or the limiting under-clearances will permit.

Stringers

1602. Stringers preferably shall be riveted between the floor beams.

Cross Frames

1603. In bridges with wooden floors and steel stringers, intermediate cross-frames (or diaphragms) shall be placed between stringers more than 20 feet long.

Floor Beams

1604. Floor beams preferably shall be at right angles to the trusses or main girders and shall be rigidly connected thereto. Usually floor-beam connections shall be located above the bottom chord and, in riveted work, the bottom lateral system shall engage both the bottom chord and the floor beam. In pin-connected trusses, if the floor beams are located below the bottom-chord pins, the vertical posts shall be extended below the pins to make a rigid connection to the floor beam.

End Floor Beams

1605. There shall be end floor beams in all square-ended truss and girder spans and preferably in skew spans. End floor beams for truss spans preferably shall be designed to permit the use of jacks for lifting the superstructure.

End floor beams shall be arranged to permit painting of the side of the beam adjacent to the abutment backwall.

End Panels

1606. In skew bridges without end floor beams, the end panel stringers shall be secured in correct position by end struts connected to the stringers and to the main trusses or girders. The end panel lateral bracing shall be attached to the main trusses or girders and also to the end struts. Adequate provision shall be made for the expansion movement of stringers.

End Connections of Floor Beams and Stringers

1607. The end connection angles of floor beams and stringers shall be not less than 3/8 in. in finished thickness. Except in cases of special end floor beam details, each end connection for floor beams and stringers shall be made with two angles. The length of these angles shall be as great as the flanges will permit. Bracket or shelf angles which may be used to furnish support during erection shall not be considered in determining the number of rivets required to transmit end shear.

End connection details shall be designed with special care to provide clearance for the driving of field connection rivets.

Where timber stringers frame into floor beams, shelf angles with stiffeners shall be provided to carry the whole reaction. Shelf angles shall be not less than 7/16 inch thick.

Any type of floor beam hanger which will permit the rotation or the longitudinal motion of the floor beam shall not be used.

Sidewalk Brackets

1608. Sidewalk brackets shall be connected in such a way that the bending stresses will be transferred directly to the floor beams.

Expansion Joints

1609. To provide for expansion and contraction movement, floor expansion joints shall be provided at the expansion ends of all spans and at other points where they may be necessary.

Apron plates, when used, shall be designed to bridge the joint and to the bridge seats. Preferably they shall be connected rigidly to the end floor beam.

Section XVII

BRACING

Design of Bracing

1701. Bracing shall be composed of angles or other shapes and the connections shall be riveted.

If a double system of bracing is used, both systems may be considered effective simultaneously if the members meet the requirements both as tension and compression members. The members shall be riveted at their intersections.

Minimum Size of Angles

1702. The smallest angle used in bracing shall be 3 by 2½ inches.

There shall be not less than three rivets in each end connection of the angles.

Lateral Bracing

1703. Bottom lateral bracing shall be provided in all spans except I-beam spans and deck plate girder spans of 50 feet or less. Bottom laterals shall be supported at their intersections by rigid hangers, if necessary, to prevent excessive deflection.

Top lateral bracing shall be provided in deck spans, and in through spans having sufficient head room.

The lateral bracing of compression chords preferably shall be as deep as the chords and effectively connected to both flanges.

Portal and Sway Bracing

1704. Through truss spans shall have portal bracing, preferably of the two plane or box type, rigidly connected to the end post and the top chord flanges, and as deep as the clearance will allow. If a single plane portal is used it shall be located preferably in the central transverse plane of the end posts, with diaphragms between the webs of the posts to provide for a distribution of the portal stresses. The portal bracing shall be designed to take the full end reaction of the top chord lateral system and the end posts shall be designed to transfer this reaction to the truss bearings.

Deck truss spans shall have sway bracing in the plane of the end posts and at all intermediate panel points. This bracing shall extend the full depth of the trusses below the floor system. The end sway bracing shall be proportioned to carry the entire upper lateral stress to the supports through the end posts of the truss.

Through truss spans shall have sway bracing at each intermediate panel point if the height of the trusses is such as to permit a depth of 5 feet or more for the bracing. When the height of the trusses will not permit of such depth, the top lateral struts shall be provided with knee braces. Top lateral struts shall be at least as deep as the top chord.

Deck Plate Girder Spans

1705. Deck plate girder spans shall be provided with cross frames at each end, proportioned to resist the lateral forces, and shall have intermediate cross frames at intervals not exceeding 20 feet. Cross frames shall be connected to the outstanding legs of the stiffener angles and to the girder flanges.

Half-Through Truss Spans

1706. The vertical truss members and the floor beam connections of half-through truss spans shall be proportioned to resist a lateral force, applied at the top chord panel points of the truss, determined by the following equation:

$R = 150\,(A + P)$ in which:
R = lateral force in pounds.
A = area of cross section of the chord in square inches.
P = panel length in feet.

This rigidity may be secured in part by extending one or both of the floor beam connection angles upward along the inside of the post and by providing a solid web in the post.

If outrigger brackets are used they shall be effectively connected to the floor beam.

Through Plate Girder Spans

1707. Through plate-girder spans shall be stiffened against lateral deformation by means of gusset plates, or knee braces with solid webs, attached to the stiffener angles and floor beams. These braces generally shall extend to the clearance line. If the unsupported length of the inclined edge of the gusset plate exceeds 60 times its thickness, the gusset plate shall have one or two stiffening angles riveted along its edge.

Bracing of Long Columns

1708. The bracing of long columns shall be designed to fix the column in both the lateral and the longitudinal directions, at or near the same point.

Section XVIII

PLATE GIRDERS

Design of Plate Girders

1801. Plate girders shall be proportioned either by the moment of inertia of their net sections, including compression side; or by assuming that the flanges are concentrated at their centers of gravity. In the latter case, one-eighth of the gross section of the web, if the web is effectively spliced, may be considered as flange section. For girders having unusual sections, the moment of inertia method shall be used.

Flange Sections

1802. The flange angles shall form as large a part of the area of the flange as practicable. Side plates shall not be used except where flange angles exceeding ⅞ inch in thickness otherwise would be required.

The gross area of the compression flange shall be not less than the gross area of the tension flange.

Flange plates shall be of equal thickness, or shall decrease in thickness from the flange angles outward. No plate shall have a thickness greater than that of the flange angles.

If flange plates are used, at least one plate on the top flange shall extend the full length of the girder, except where the flange is to be covered with concrete. Any additional flange plates shall extend at least one foot beyond the theoretical end, and there shall be a sufficient number of rivets at each end of each plate to develop its full stress value before the end of the next outside plate is reached.

Thickness of Web Plates

1803. The thickness of web plates, except those to be encased in concrete, shall be not less than $\frac{1}{20}\sqrt{D}$, in which D is the distance in inches between flanges.

Flange Rivets

1804. The number of rivets connecting the flange angles to the web plate shall be sufficient to develop the increment of flange stress transmitted to the flange angles, combined with any load that is applied directly to the flange. For electric railways, one wheel load, when applied directly to the flange, shall be assumed to be distributed uniformly over a length of 3 feet.

Flange Splices

1805. Splices in flange parts shall not be used except by special permission of the Engineer. Not more than one part shall be spliced at the same cross section. If practicable, splices shall be located at points where there is an excess of section. The net section of the splice shall exceed by 10 per cent the net section of the part spliced. Flange angle splices shall consist of two angles, one on each side of the girder.

Web Splices

1806. Web plates shall be spliced symmetrically by plates on each side. The splice shall be equal to the web in strength in both shear and moment. The splice plates for shear shall be of the full depth of the girder between flanges. In the splice, there shall be not less than two rows of rivets on each side of the joint.

End Stiffeners

1807. Over the end bearings of plate girders, there shall be stiffener angles, the outstanding legs of which shall extend as nearly as practicable to the outer edge of the flange angles. End stiffeners shall be proportioned for bearing on the outstanding legs of the flange angles, no allowance being made for the portions of the legs fitted to the fillets of the flange angles. End stiffeners shall be arranged, and there shall be a sufficient number of rivets in their connection to the web, to transmit the entire end reaction to the bearings. They shall not be crimped.

Intermediate Stiffeners

1808. The webs of plate girders shall be stiffened by angles not greater than:

(a) 6 feet;
(b) The depth of the web;
(c) The distance given by the formula

$$d = 100t\sqrt{\frac{24000}{S} - 1}, \text{ in which}$$

d = clear distance between stiffeners, in inches.
t = thickness of web, in inches.
S = unit shearing stress in the gross vertical section of the web due to dead load, and the live load increased as specified in Article 1301.

If the depth of the web between the flange angles, or between the side plates, if there are side plates, is less than 60 times the thickness of the web, intermediate stiffeners may be omitted.

Intermediate stiffener angles shall be placed at points of concentrated loading and shall be so designed as to transmit the reactions to the girder web. Such stiffeners shall not be crimped.

Intermediate stiffener angles shall be riveted in pairs to the web of the girder. The width of the outstanding leg shall not be more than 16 times its thickness, and not less than 2 inches plus one-thirtieth of the depth of the girder.

Ends of Through Girders

1809. The upper corners of through plate girders, where exposed, shall be rounded to a radius consistent with the size of the flange angles and the vertical height of the girder above the roadway. The first flange plate or a plate of the same width shall be bent around the curve and continued to the bottom of the girder. In a bridge consisting of two or more spans, only the corners at the extreme ends of the bridge need be so rounded unless the spans have girders of different heights. In such a case the higher girders shall have their top flanges curved down at the ends to meet the top corners of the girders in the adjacent spans.

Sole Plates

1810. Sole plates of plate girders shall have a thickness of not less than ¾ inch and not less than the thickness of the flange angles plus ⅛ inch. Preferably they shall not be longer than 18 inches.

Masonry Bearings

1811. Ends of girders on masonry shall be so supported on metal pedestals that the bottom flanges will be above the bridge seat, preferably not less than 6 inches.

Camber

1812. In general, camber will not be required in plate girders except for long spans or special conditions. When required, it shall be in the amount specified by the Engineer.

Section XIX

TRUSSES

Main Features

1901. Preference will be given to trusses with single intersection web systems. Members shall be symmetrical about the central plane of the truss.

Trusses preferably shall have inclined end posts. Half-through trusses shall be of the riveted type. Laterally unsupported hip joints shall be avoided.

Top Chords and End Posts

1902. Top chords and end posts usually shall be made of two side segments with one cover plate, and with stay plates and lacing on the open side. In chords of light section, stay plates and lacing may be used in place of the cover plate.

If the shape of the truss permits, compression chords shall be continuous. The splices shall be as near the panel points as practicable and preferably on the side of the panel point where the smaller stress occurs.

The top-chord sections of half-through truss spans shall be so proportioned that the radius of gyration about the vertical axis of the member will be at least one and one-half times that about the horizontal axis.

Bottom Chords

1903. The bottom chords of riveted trusses generally shall be spliced near panel points and on the side of the panel point where the smaller stress occurs.

In bottom chords composed of angles, the vertical legs of the angles preferably shall extend downward.

Working Lines and Gravity Axes

1904. In compression members of unsymmetrical section, such as chord sections formed of side segments and a cover plate, the gravity axis of the section shall coincide as nearly as practicable with the working line, except that eccentricity may be introduced to counteract dead load bending. In two-angle bottom chord or diagonal members, the working line may be taken as the gage line nearest the back of the angle.

Camber

1905. The length of the truss members shall be such that the camber will be equal to or greater than the deflection produced by the dead load plus the full live load without impact. Ordinarily this will be accomplished by increasing the length of the top chord approximately $\frac{3}{16}$ in. for each 10 feet of its horizontal projection.

Riveted Tension Members in Pin-Connected Trusses

1906. In pin-connected trusses, the hip verticals and members performing similar functions, and the bottom chords in the first two panels at each end, shall be riveted members.

Counters

1907. If web members are subject to reversal of stress, their end connections shall be riveted. Counters preferably shall be rigid. Adjustable counters, if used, shall have open turnbuckles, and in the design of these members an allowance of 10,000 lb. shall be made for initial stress. Only one set of diagonals in any panel shall be adjustable. Sleeve nuts and loop bars shall not be used.

Eye-Bars

1908. The thickness of eye-bars shall be not less than one-eighth of the width, not less than one-half inch, and not greater than 2 inches. The section of the head through the center of the pin hole shall exceed that of the body of the bar by at least 35 per cent. The form of the head shall be submitted to the Engineer for approval before the bars are made. The diameter of the pin shall be not less than three-fourths of the width of the widest bar through which it passes.

Packing of Eye-Bars

1909. The eye-bars of a set shall be symmetrical about the central plane of the truss and as nearly parallel as practicable. The inclination of any bar to the plane of the truss shall not exceed $\frac{1}{16}$ inch to a foot. Bars shall be as close together as practicable and held against lateral movement, but they shall be so arranged that adjacent bars in the same panel will be separated by at least ½ inch.

Intersecting diagonal bars not far enough apart to clear each other at all times shall be clamped together at the intersection.

Steel filling rings shall be provided, if needed, to prevent lateral movement of eye-bars or other members connected on the pin.

Diaphragms

1910. There shall be diaphragms in the trusses at the end connections of floor beams.

The gusset plates engaging the pedestal pin at the end of the truss shall be connected by a diaphragm. Similarly, the webs of the pedestal shall, if practicable, be connected by a diaphragm.

There shall be a diaphragm between gusset plates engaging main members if the end tie plate is 4 feet or more from the point of intersection of the members.

Sole Plates

1911. Sole plates of trusses shall be not less than ¾ inch thick.

Masonry Bearings

1912. Trusses on masonry shall be so supported on metal plates or pedestals that the bottom chords will be above the bridge seat, preferably not less than 6 inches.

Section XX

VIADUCTS

Type

2001. Viaducts shall consist of plate girders or riveted trusses supported on bents, and usually arranged in alternate tower spans and free spans.

Bents and Towers

2002. Bents preferably shall be composed of two supporting columns, and the bents usually shall be united in pairs to form towers.

Batter

2003. Bents preferably shall have a sufficient spread at the base to prevent uplift under the assumed lateral loadings. In general, the width of a bent at its base shall be not less than one-third of its height.

Single Bents

2004. Single bents shall have hinged ends or else shall be designed to resist bending.

Bracing

2005. Towers shall be braced, both transversely and longitudinally, with stiff members having riveted connections. The sections of members of longitudinal bracing in each panel shall not be less than those of the members in corresponding panels of the transverse bracing.

Column splices shall be above and close to the panel points of the bracing.

Bottom Struts

2006. The bottom struts of viaduct towers shall be strong enough to slide the movable shoes with the structure unloaded, the coefficient of friction being assumed as 0.25. Provision for expansion of the tower bracing shall be made in the column bearings.

Depth of Girders

2007. The depths of girders in viaducts preferably shall be uniform.

Girder Connections and Bracing

2008. Girders of tower spans shall be fastened at each end to the tops of the columns or to the cross girders. Preferably there shall be a line of girders resting directly over the columns. One end of the girders between towers shall be riveted to the support, and there shall be an effective expansion bearing at the other end. No bracing or sway frame shall be common to abutting spans.

If girders are not supported directly on the columns, provision shall be made for the transmission of the longitudinal forces to the tower bracing.

Sole and Masonry Plates

2009. Sole plates, masonry plates, and cap plates shall be not less than ¾ inch thick.

Table of Moments, Shears and Floorbeam Reactions for H-20 Loading —One Lane

MOMENT IN THOUSANDS OF FOOT POUNDS—SHEARS AND REACTIONS IN THOUSANDS OF POUNDS

	Shear		Moment		F.B. Reaction	
Span	*L.L.*	*Impact*	*L.L.*	*Impact*	*L.L.*	*Impact*
5	32.0	12.3	40.0	15.4	32.0	11.9
6	32.0	12.2	48.0	18.3	32.0	11.7
7	32.0	12.1	56.0	21.2	32.0	11.5
8	32.0	12.0	64.0	24.1	32.0	11.3
9	32.0	11.9	72.0	26.9	32.0	11.2
10	32.0	11.9	80.0	29.6	32.0	11.0
11	32.0	11.8	88.0	32.3	32.0	10.9
12	32.0	11.7	96.0	35.0	32.0	10.7
13	32.0	11.6	104.0	37.7	32.0	10.6
14	32.0	11.5	112.0	40.3	32.0	10.5
15	32.5	11.6	120.0	42.9	32.5	10.5
16	33.0	11.7	128.0	45.4	33.0	10.5
17	33.4	11.8	136.0	47.9	33.4	10.5
18	33.8	11.8	144.0	50.3	33.8	10.5
19	34.1	11.8	152.0	52.8	34.1	10.5
20	34.4	11.9	160.0	55.2	34.4	10.4
21	34.7	11.9	168.0	57.5	34.7	10.4
22	34.9	11.9	176.0	59.9	34.9	10.3
23	35.1	11.9	184.0	62.2	35.1	10.3
24	35.3	11.9	192.0	64.4	35.3	10.2
25	35.5	11.8	200.0	66.7	35.5	10.1
26	35.7	11.8	208.0	68.9	35.7	10.1
27	35.9	11.8	216.9	71.3	35.9	10.0
28	36.0	11.8	226.8	74.1	36.0	9.9
29	36.1	11.7	236.7	76.9	36.1	9.9
30	36.3	11.7	246.6	79.6	36.3	9.8
31	36.4	11.7	256.5	82.2	36.6	9.8
32	36.5	11.6	266.5	84.9	36.9	9.8
33	36.6	11.6	276.4	87.5	37.2	9.7
34	36.7	11.5	286.3	90.0	37.4	9.7
35	36.8	11.5	296.2	92.6	37.7	9.7
36	36.9	11.5	306.2	95.1	37.9	9.6
37	37.0	11.4	316.1	97.6	38.1	9.6
38	37.1	11.4	326.1	100.0	38.3	9.5
39	37.1	11.3	336.0	102.4	38.5	9.5
40	37.2	11.3	346.0	104.8	38.7	9.4
41	37.3	11.2	355.9	107.2	38.9	9.4
42	37.3	11.2	365.9	109.5	39.0	9.3
43	37.4	11.1	375.8	111.8	39.2	9.3
44	37.5	11.1	385.8	114.1	39.4	9.2
45	38.0	11.2	395.7	116.4	40.6	9.4

Table of Moments, Shears and Floorbeam Reactions for H-20 Loading —One Lane—Continued

Moment in Thousands of Foot Pounds—Shears and Reactions in Thousands of Pounds

	Shear		Moment		F.B. Reaction	
Span	*L.L.*	*Impact*	*L.L.*	*Impact*	*L.L.*	*Impact*
46	38.6	11.3	405.7	118.6	41.7	9.6
47	39.2	11.4	415.7	120.8	42.8	9.8
48	39.7	11.5	425.6	123.0	43.9	9.9
49	40.2	11.5	435.6	125.2	44.9	10.1
50	40.6	11.6	445.6	127.3	45.9	10.2
51	41.1	11.7	455.5	129.4	46.9	10.3
52	41.5	11.7	465.5	131.5	47.8	10.4
53	42.0	11.8	475.5	133.6	48.6	10.5
54	42.4	11.8	485.5	135.6	49.5	10.6
55	42.8	11.9	495.4	137.6	50.3	10.7
56	43.1	11.9	505.4	139.6	51.1	10.8
57	43.5	12.0	515.4	141.6	51.8	10.8
58	43.9	12.0	525.4	143.5	52.6	10.9
59	44.3	12.0	535.3	145.5	53.4	11.0
60	44.7	12.1	545.3	147.4	54.1	11.0

Appendix B

(3) FEASIBILITY OF ELECTRIC WELDING OF CONNECTIONS IN STEEL STRUCTURES

Albert Reichmann, Chairman, Sub-Committee; Thos. Earle, G. H. Gilbert, C. S. Heritage, R. M. Stubbs, G. H. Tinker, P. B. Spencer.

This Committee makes the following report and recommends that it be received as information:

The A.R.E.A. Specifications for Steel Railway Bridges do not permit the use of welding for bridge work; nevertheless, welding is used very extensively for light structural work, tanks, reinforcement in old structures, etc. A number of fairly good sized buildings have been completely fabricated and welded in the field. One of the first of any size was for the Westinghouse Electric & Manufacturing Company, at Sharon, Pa.

More recently the General Electric Company erected a structure in Philadelphia, for which the material was electrically welded both in the shop and in the field.

In the early part of 1927, the Chicago Great Western Railway Company's bridge over the Missouri River, at Leavenworth, Kansas, was reinforced by means of electric welding and is giving very satisfactory service.

The first all-welded through truss railroad bridge to be put in service in this country was built by the Westinghouse Electric & Manufacturing Co. over a power canal at Chicopee Falls, Mass. This bridge is a single track, single span structure of the Warren truss type, with sub-divided panels, and owing to the angle of crossing of the power canal, has a 72-degree skew. The length of each truss is 134 feet 8 inches, but owing to the skew of the bridge, its over-all length is about 175 feet. The width of the bridge between trusses is 17 feet, and the vertical height between the chords of each truss is 24 feet 8 inches.

Up to the present time, the art of welding has not advanced sufficiently to warrant its use in the fabrication of structural steel for railway bridges. For those desiring to use electric welding as a means of strengthening steel structures, it might be of interest to see the Journal of the American Welding Society of April, 1928, which gives results of tests made by the Rensselaer Polytechnic Institute for the General Electric Company. It will be noted for specimens in tension the 3/8 inch by 3/8 inch triangular fillets of varying lengths gave an average longitudinal shearing strength of 13,300 pounds per linear inch of fillet; whereas, compression specimens with varying lengths of 3/8 inch by 3/8 inch fillets gave from 17,800 to 15,800 pounds ultimate shearing strength per linear inch of fillet. It would seem reasonable that 3000 pounds per linear inch in design would give ample security.

Appendix C

(7) USES OF COPPER BEARING STEEL FOR STRUCTURAL PURPOSES

F. P. Turner, Chairman, Sub-Committee; P. S. Baker, Thos. Earle, W. S. Lacher, C. E. Sloan, G. H. Trout.

This Committee makes the following report and recommends that it be received as information:

Information collected indicates the increased use of copper bearing steel for various industrial and structural purposes; it is now being used in the manufacture of steel cars, tie plates, track spikes, smokestacks, stationary boilers, metal culvert pipes, metal flashings, ventilators, wire fencing, light structural steel for warehouses, steel sash, power line supports, flood light towers, and overhead electrification structures for railway tracks.

Copper bearing steel in such service has, in many instances, been found to last one and one-half times as long as ordinary steel.

No comparative tests have been made on the life obtained by the use of copper bearing steel in either railway steel bridges or highway steel bridges; records of construction show that, during the year 1928 two of our large railway systems have specified and purchased copper bearing steel for use in a number of railway steel bridges, and manufacturers of steel report a gradual increase in production of copper bearing structural steel for structural and miscellaneous purposes.

Copper bearing steel has been used for three years in the manufacture of several important highway bridges; sufficient time has not elapsed to determine comparative results.

Service tests on copper bearing steel used in the manufacture of railway tie plates, over a period of five years, show:

Copper treated steel....................2% loss in weight,
Non-Copper treated steel..............7% loss in weight
Wrought iron ....7% loss in weight

Similar tests on copper treated steel, for tie plates, over a period of eleven years, show:

Copper treated steel.................. 5% loss in weight
Non-copper treated steel..............20% loss in weight

Tests on cut railroad spikes, over a period of six years, indicate the following:

Copper treated steel.................. 9% loss in weight
Non-copper treated steel..............15% loss in weight

Tests on steel freight cars, 200 of which were manufactured and placed in service in 1914, one-half of each car being manufactured from copper bearing steel, and the other half from plain steel, indicate, after six years and thirteen years' service, respectively, the following relative loss in weight:

After Six Years' Service

Average loss in thickness, copper bearing steel, 8%.
Average loss in thickness, plain open hearth steel, 18%.

After Thirteen Years' Service

Average loss in thickness, copper bearing steel, 32%.
Average loss in thickness, plain open hearth steel, 57%.

More definite results on comparative service were obtained by cutting to pieces one of the above described cars, after thirteen years' service, cleaning and washing the resulting sheets, which were taken from all parts of the car body.

This test showed average loss in weight on sheets taken from six different locations of the car, as follows:

Plain steel	44.7%
Copper bearing steel	27.3%

The average loss in weight compares quite favorably with the average loss in thickness, as obtained by measurements.

Paint adheres to copper bearing steel sheets much better than to plain steel sheets on freight cars; observation and repairs on the above described cars indicated that the painting of cars manufactured from plain open hearth steel was necessary at more frequent intervals, than painting of cars manufactured from copper bearing steel.

Results of tests on car bodies, manufactured as described above, led the owners to conclude that the average life would be increased from one-third to one-half, or in round numbers, from five to eight years, and that this additional life more than justifies the slight extra cost per ton for the copper bearing steel.

Below is a summary of the above described comparative service tests on the 200 freight cars:

1. Paint adheres very much better to copper bearing steel in a car body than it does to plain open hearth steel.

2. The saving in repainting cars, due to better adherence of paint to copper bearing steel, would be sufficient to justify the use of copper bearing steel in the bodies of steel freight cars.

3. Where mechanical abrasion has not been a serious factor, as in the side sheets of gondolas, the loss in thickness for the copper bearing steel was only one-third as great as for the plain open hearth steel.

4. Where the steel was subjected to severe mechanical abrasion as well as corrosion, the loss in thickness for the copper bearing steel was approximately 60 per cent as great as for the plain open hearth steel

5. From the results of this investigation it can be conservatively stated that the use of copper bearing steel in the body of the cars would increase the life of the car body from 33⅓ to 50 per cent.

Other atmospheric tests on uncoated steel sheets, over a period of seven years, in a steel manufacturing district where smoke and gases prevail in the atmosphere, indicate that:

For No. 16 gage sheets ($\frac{1}{16}$ inch thick), 80 per cent of all non-copper bearing sheets failed in seventy-five months.

None of the copper bearing sheets failed within the same period.

For No. 22 gage sheets ($\frac{1}{32}$ inch thick), non-copper bearing sheet failed within twenty-three months—average life of copper bearing sheets forty-nine months.

Information collected shows that the use of copper bearing steel for structural purposes is widening, and its use is now extending to roof trusses in railway enginehouses and shop buildings that are exposed to marked corrosive influences, to foot bridges over railway yards, and in some instances, to turntables.

Copper bearing steel can readily be secured at a slight increased cost, orders for copper bearing steel are promptly filled, and the manufacturers indicate a spirit of co-operation in its introduction for structural purposes.

Appendix D

(8) EFFECT OF DEAD LOAD ON IMPACT FROM MOVING LOADS ON BRIDGES

F. E. Turneaure, Chairman, Sub-Committee; J. E. Bernhardt, R. P. Davis, O. F. Dalstrom, Otis Hovey, J. B. Hunley, W. S. Lacher, B. R. Leffler, I. L. Simmons, S. M. Smith.

This Committee makes the following report and recommends it be received as information:

EFFECT OF DEAD LOAD ON IMPACT

By F. E. Turneaure

Theory

A theoretical analysis of impact due to unbalanced locomotive drivers when moving at the critical speed indicates that the impact is

$$I = K \frac{G\,r}{(w + p)\,cd} \qquad \text{(1)}$$

in which

K = some constant.
G = total weight of overbalance at crank pin center.
r = radius of crank pin circle.
w = dead load per foot.
p = live load per foot.
c = circumference of driver.
d = deflection of truss due to live load.

The analysis is given in Proceedings of American Railway Engineering Association, Vol. 12, part 3, 1911, p. 29. This identical relation has also been worked out by the Indian Railway Board and reported in Proceedings of the American Railway Engineering Association, Vol. 28, 1927, p. 776. The Indian Railway Board has applied this formula to test results of their own work and of the American Railway Engineering Association with a fair amount of agreement (see page 779).

The same general relations are deduced by Professor Timoshenko. (See Philosophical Magazine, Vol. 43, 1922).

It is important to note that, according to this analysis, the impact percentage is proportional to the quantity $\frac{G\,r}{c}$, which is a function of the locomotive, and inversely proportional to the total load and to the deflection. The effect of span length is taken into account in the items $(w+p)$ and d, both of these increasing with span length. The critical speed is less the greater the values of $(w+p)$ and d.

While a pure theoretical analysis is hardly sufficient in such an involved problem, yet it is very valuable as an indication of the general effect of the different variables and as a guide in arranging proper conditions for any program of tests.

Theoretical Effect of Dead Load and Deflection

Assuming the locomotive factor $\frac{G\,r}{c}$ to be constant the impact will be

$$I=\frac{K}{(w+p)\,d} \qquad \text{(2)}$$

(a) If w and p remain constant, but one truss is shallower than the other, its deflection will be greater and the impact less. This is due primarily to the slower rate of vibration, and hence lower critical speed.

(b) The effect of an increased live load p on the same structure is to lessen the percentage of impact, both by increasing p and increasing d. If the locomotive factor $\frac{G\,r}{c}$ is increased proportionately to p, then the decrease in impact will be much less, but there will be some. This general effect of an increased live load is well to bear in mind in using impact data secured by the use of light trains. The impact *percentages* so obtained will most likely be *larger* than those obtained by heavier or maximum loads. This principle is reassuring when considering the effect of an overload.

(c) Given two structures one heavier than the other, but so proportioned that the live load deflection is the same for both. The value of w is alone increased. The impact will then be less for the heavier structure. If $w=\frac{1}{2}p$ in the lighter structure and the heavier one is 10 per cent heavier, then the impact will be 3⅓ per cent less in the latter structure.

(d) Given two structures of the same length and general dimensions and designed for the same live load and impact. Under these conditions the deflection of the two structures for dead load, full load and impact will be the same, being a function of general dimensions and working stresses.

Let I_1 and I_2 = theoretical impact ratios for the two structures under full live load.
w_1 and w_2 = dead loads per foot of the two structures.
p = live load per foot.
I = impact ratio assumed in the design, the same in both.
d_1 and d_2 = deflection due to live load p.
D = deflection of each structure due to dead load, live load and impact.

Then by the theoretical impact formula

$$\frac{I_1}{I_2} = \frac{(w_2 + p)d_2}{(w_1 + p)d_1} \qquad \text{(3)}$$

Since deflections are proportional to load

$$\frac{d_1}{D} = \frac{p}{w_1 + (1 + I)p}; \quad \frac{d_2}{D} = \frac{p}{w_2 + (1 + I)p}$$

$$\text{hence } \frac{d_2}{d_1} = \frac{w_1 + (1 + I)p}{w_2 + (1 + I)p}$$

Substituting in (3) we have

$$\frac{I_1}{I_2} = \frac{(w_2 + p)\ (w_1 + p + Ip)}{(w_1 + p)\ (w_2 + p + Ip)} \qquad \text{(4)}$$

Suppose for example, $I = .6$, $w_1 = .5p$ and $w_2 = p$.

For these values there results $\frac{I_1}{I_2} = 1.08$.

That is, where the dead load of the lighter bridge is equal to one half of the live load, and the dead load of the heavier structure is twice as great and the impact assumed in the design is 60 per cent, the theoretical impact for the lighter structure is 8 per cent more than for the heavier.

In general the larger the assumed impact the greater the effect; also the larger the actual dead loads and the larger their differences the greater the effect.

As an extreme example assume a very short span for which the assumed impact is 90 per cent; also $w^1 = .2p$, $w_2 = .8p$.

$$\text{Then } \frac{I_1}{I_2} = 1.17.$$

If the heavier of these two structures were actually designed for a lower value of impact represented by the formula the deflection under live load would have been somewhat greater and the ratio I_1/I_2 would have been somewhat greater.

For loads in excess of the design load the heavier structure will have somewhat greater advantage than above indicated.

Theoretical results therefore indicate some effect of dead load, the amount of which in most cases would probably be from 5 to 15 per cent.

RESULTS OF TESTS

Some further study has been made on the old American Railway Engineering Association tests in an effort to analyze the effect of dead load. The various structures have been placed in two general groups—the relatively light (ordinary open floor bridge) and the relatively heavy (generally ballasted floors). Results are given in Tables I and II. Deflection results only have been used, as these are more reliable and consistent. The impact values of the two groups have also been spotted in the diagram, Fig. 1. Many of the heavier spans are double track, which introduces other factors difficult to take account of, the principal one being, no doubt, the lesser deflection. Readings were, however, always taken in the most stressed girder or truss, so that the error from this factor would not be very great. However, if the other track had also been fully loaded with a stationary load, the impact would doubtless have been considerably less. This condition under which the tests were made favors a rather cautious procedure in applying impact formulas to double track bridges. A detailed study of the tabulated data will show the results to be quite erratic in many respects, but of course the effect of span length on deflection is apparent. Not much difference can be observed between results of the two groups, although the heavy structures show a somewhat lower value (Fig. 1) for the longer spans (100-200 ft.) than the lighter ones.

Some further information may be obtained by comparing the test results with the theory expressed in Eq. (1). The value of the "constant" K is

$$K = I \frac{(w + p)d}{Gr/c} \qquad (5)$$

From this equation we may calculate the values of K directly from the data of Tables I and II. The results of this calculation are given in Tables III and IV.

The values of K thus calculated are seen to be very variable as might be expected in work of this kind, but by averaging the results in groups we may discover some definite trend in values.

From Table III, the average value of K is 125, or if we omit the abnormal value of 490, the average is 99. The average for the first 8 spans (up to 132 ft.) is 104, and for the last 6 spans (152 to 300 ft., omitting No. 34) is 92.

From Table IV, the average value of K is 117, or if we omit the single large value of 208, the average is 110. The average for the first 8 spans (up to 80 ft.) is 110 and for the last 6 spans (92 ft. 6 in. up to 440 ft., omitting No. 42) is also 110.

From these averages it would appear that the value of K for the heavier spans is at least as large as for the lighter spans, indicating that the formula takes full account of the effect of dead load.

An interesting and significant result is that the average values of K for the shorter and for the longer spans is practically the same which tends strongly to support the fundamental correctness of the formula at least so far as length of span (represented by deflection) is concerned.

The effect of variation of Gr/c, the locomotive coefficient, may also be noted to some extent by grouping the results according to the values of this coefficient. Dividing the results into two nearly equal groups, the one for values of Gr/c less than 900 and the other for values greater than 900, we find the following average values for K:

Light spans:

Average value of $\frac{Gr}{c} = 668$; average value of $K = 114$.

Average value of $\frac{Gr}{c} = 1232$; average value of $K = 87$.

Heavy spans:

Average value of $\frac{Gr}{c} = 697$; average value of $K = 129$.

Average value of $\frac{Gr}{c} = 1303$; average value of $K = 81$.

All spans:

Average $\frac{Gr}{c} = 682$; average value of $K = 122$.

Average $\frac{Gr}{c} = 1262$; average value of $K = 84$.

From these results it appears that the impact does not increase proportionately with $\frac{Gr}{c}$ but at a less rate.

A

TABLE 1—TEST DATA FOR SPANS OF LESSER DEAD LOAD. IMPACT FROM DEFLECTION RESULTS.

R.R.	No. of Bridge	Span in Feet	Weight per foot (1000 lb.)	Deflection in inches	Impact percent	Speed mi. per hr.	Locomotive number	$\frac{G.r}{c}$	Approx. L.L. per ft. (1000 lb.)
Rock Island	15	44	—	0.21	22	60	819	775	7.6
Ill. Cent.	7	45	1.69	0.18 0.18	45 61	55 53	34 234	577	5.8 5.7
N.&W.	35	48	1.12	0.34	24	33	1,059	862	6.6
Rock Island	29	50	1.10	0.23	67	48	1,746	1,090	6.8
N.Y.C.	44	53'-10"	—	0.26	36	63	3,883	580	5.8
Rock Island	31	60	1.56	0.27	40	41	2,200	1,322	6.65
C.M.&St.P.	19	65'-6"	1.29	0.32	48	64	263	921	4.6
Rock Island	30	100	2.01	0.53	46	40	2,200	1,322	4.31
Rock Island	28	124	2.0	0.38	36	44	1,746	1,108	3.25
Ill. Cent.	6	126'-8"	2.55	0.28	41	52	34	—	3.35
C.B.&Q	9	132	1.90	0.56 0.71	34_4 31	47 39	2,527 1,919	577 827	3.0 3.6
Ill. Cent.	3	135'-11"	1.98	—	30_1	60	47	—	3.6
Ill. Cent.	1	148'-6"	2.6	—	29_2 23_2	45 42	904 1,013	1,182 714	2.85 2.8
N.&W.	32	152	1.86	0.87	12	38	1,059	862	4.2
Rock Island	14	152'-6"	2.17	0.46	22	43	819	774	3.75
N.&W.	34	152'-10"	1.86	0.82	39	35	603	386	4.10
Ill. Cent.	2	156'-9"	1.88	—	22_3	50+	1,018	764	3.55
C.M.&St.P.	17	159'-9"	2.68	0.40	23	46	939	1,460	3.6
C.M.&St.P.	12	176'-6"	—	0.71	33	44	925	1,460	3.4
Santa Fe	27	210	2.7	0.80	24	33	1,066	1,316	3.75
Nickle Plate	16	228	2.25	0.81	13 22_4	33 58	185	357	3.2
Santa Fe	26	300	3.7	0.97	22	25	1,066	1,316	2.93

1. Top chord; 2. End post; 3. Chords; 4. Bad car

All single track spans.

TABLE 2—TEST DATA FOR SPANS OF GREATER DEAD LOAD. IMPACT FROM DEFLECTION RESULTS.

R.R.	No. of Bridge	Span in Feet	Weight per foot (1000 lb)	Deflection in Inches	Impact percent	Speed mi. per hr.	Locomotive number	$\frac{Gr}{c}$	Approx L.L. per ft. (1000 lb)
Penna.R.R.	41_{BD}	37	9.3	{0.075 0.06	67 58	64+ 67	7,204 7,027	865 492}	7±
Penna.R.R.	43_{BD}	49	9.8	{0.10 0.12	45 75	65 75	7,027 7,204	492 865	6.5 6.8
Penna.R.R.	40_{BD}	59'-2"	9.3	0.18	53	58	7,204	865	5.7
Santa Fe	21_{BD}	64	3.2	0.22	32	50+	573	1,476	4.7
C.M.&St.P.	20_{B}	70	4.6	0.175	51	63	263	921	4.3
Santa Fe	25_{B}	70	3.1	0.41	27	45	1,115	1,316	5.15
Penna.R.R.	38_{B}	77'-10"	6±	0.13	52	50	7.027	492	3.2
C.M.&St.P.	13_{B}	80	3.0	0.285	42	55	304	808	3.95
Santa Fe	22_{BD}	92'-6"	3.2	0.305	39	45	573	1,476	4.8
Penna.R.R.	42_{D}	104	4.85	0.24	50	62	7,027	492	3.65
Ill.Cent.	5	112	3.62	0.3	42	51	20	–	3.8
Santa Fe	23_{BD}	124	8.6	0.38	35	42	1,115	1,316	3.75
N.&W.	36_{D}	126	4.15	0.26	27	48	494	862	4.6
Santa Fe	24_{BD}	149	8.7	0.34	31	46	1,115	1,316	3.55
Penna.R.R.	37_{D}	206	6.25	0.34	21	60	7,027	492	3.8
C.B.&Q.	45_{D}	440	7.1	1.75	5	20	2,543	577	3.12

B = Ballasted Floor. D = Double Track.

No. 21, 2 tracks 3 trusses. Weight of one track and two trusses.
No. 22, 3 girders. Weight of one track and two girders
No 36, Skew.
No 38, 4 tracks 5 girders. Total dead load = 23.5 per ft.
No 40, 3 Girders

TABLE 3—LESSER DEAD LOADS—CALCULATED VALUES OF K FROM THE DATA OF TABLE 1.

No of Bridge	Span in Feet	$w+p$	d	$\frac{Gr}{c}$	$\frac{(w+p)d}{\frac{Gr}{c}}$	I	K	Average values of K in groups
7	45	7,400	0.18	577	2.30	61	140	
35	48	7,700	0.34	862	3.05	24	73	
29	50	7,900	0.23	1,090	1.67	67	112	
31	60	8,200	0.27	1,322	1.67	40	67	Av. K
19	65.5	5,890	0.32	921	2.05	48	99	= 104
30	100	6,320	0.53	1,322	2.53	46	116	
28	124	5,250	0.38	1,108	1.80	36	65	
9	132	4,900	0.56	577	4.75	34	162	
32	152	6,060	0.87	862	6.10	12	73	
14	152.5	5,920	0.46	774	3.55	22	78	Av. K,
34	152'-10"	5,960	0.82	386	12.60	39	490	omitting 490
17	159'-9"	6,280	0.40	1,460	1.71	23	39	= 92
27	210	6,450	0.80	1,316	3.90	24	93	
16	228	5,450	0.81	357	12.40	13	161	
26	300	6,630	0.97	1,316	4.90	22	108	

Av. K = 125

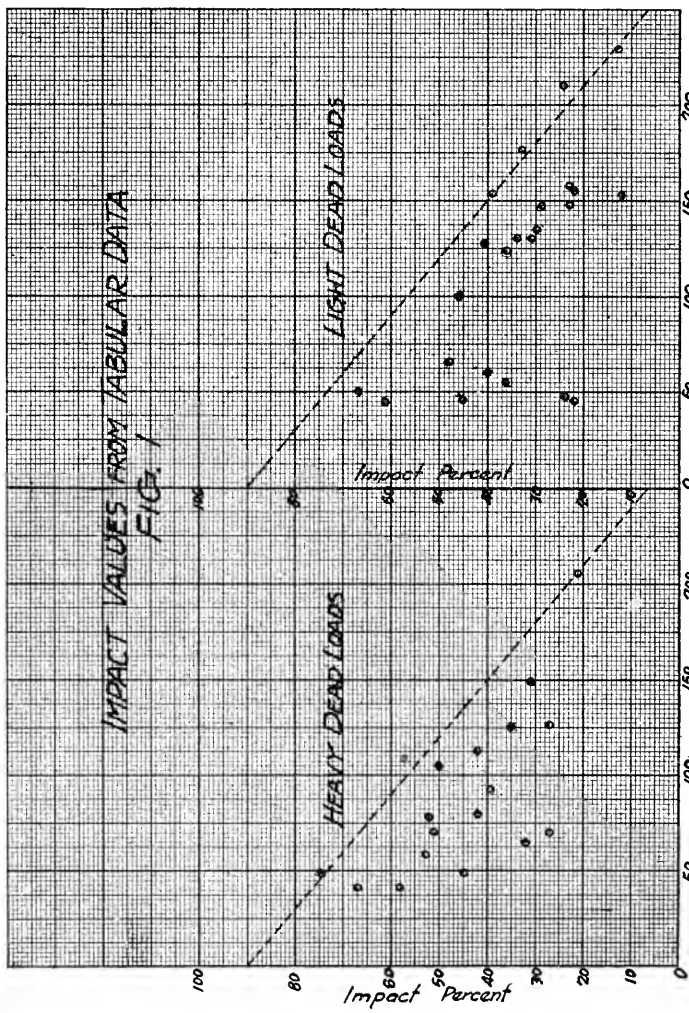
Av. K, omitting 490, is 99

TABLE 4—GREATER DEAD LOADS—CALCULATED VALUES OF K FROM THE DATA OF TABLE 2.

No of Bridge	Span in Feet	$w+p$	d	$\frac{Gr}{c}$	$\frac{(w+p)d}{\frac{Gr}{c}}$	I	K	Average values of K in groups
41	37	16,300	0.06	492	1.99	58	117	
43	49	16,600	0.12	865	2.3	75	173	
40	59'-2"	15,000	0.18	865	3.12	53	165	
21	64	7,900	0.22	1,476	1.18	32	38	Av. K
20	70	8,900	0.175	921	1.70	51	87	= 110
25	70	8,250	0.41	1,316	2.56	27	70	
38	77'-10"	9,200	0.13	492	2.43	52	127	
13	80	6,950	0.285	808	2.46	42	104	
22	92'-6"	8,000	0.305	1,476	1.66	39	65	
42	104'	8,500	0.24	492	4.15	50	208	
23	124	12,350	0.38	1,316	3.57	35	125	Av. K = 124
36	126	8,750	0.26	862	2.63	27	71	If 208 be
24	149	12,250	0.34	1,316	3.18	31	99	omitted, Av K = 110
37	206	10,050	0.34	492	6.95	21	146	
45	440	10,220	1.75	577	31.0	5	155	

Av K = 117

Av. K, omitting 208, is 110


IMPACT VALUES FROM TABULAR DATA
FIG. 1
LIGHT DEAD LOADS
HEAVY DEAD LOADS
Impact Percent
Span in feet
Impact Percent
Span in feet

Appendix E

(9) ROLLING TESTS OF PLATES

W. M. Wilson, Chairman, Sub-Committee; O. F. Dalstrom, Otis Hovey, B. R. Leffler, P. B. Motley, O. E. Selby, G. H. Tinker.

This Committee makes the following report and recommends that it be received as information:

This Committee on the Bearing Value of Large Rollers has co-operated with the University of Illinois in making extensive rolling tests during the past year. These tests were made upon plates of solid rectangular sections similar to the sole plates used on the segmental girders and track girders of bascule bridges. The plates varied in thickness from one-fourth inch to four inches and the cylinders under which they were rolled varied in diameter from 116 inches to 476 inches. Tests were made upon steel castings of medium grade when annealed and when hardened with heat treatment, upon steel of structural grade when annealed and when hardened by heat treatment, and upon an alloy steel sold under the trade name of Hylastic.

These tests were financed in part by the American Railway Engineering Association and in part by the Scherzer Rolling Bascule Bridge Company. The American Railway Association has appropriated $1,000 for the continuation of the tests another year.

A complete technical report of the tests made during the school year of 1927-28 follows:—

(I) INTRODUCTION

1. **Object and Scope of Investigation.** The object of this investigation was to study the flow of metal in a plate rolled under a loaded cylinder. This information is of interest to the designer of rolling bascule bridges and other similar structures. In one type of construction of rolling bascule bridges the segmental and track girders are faced with sole plates having solid rectangular sections. The working load for these sole plates should be based upon the minimum load that will produce a permanent deformation, and tests were planned to determine the value of this minimum load.

The investigation was planned to ascertain the effect of certain variables upon the load required to produce a permanent deformation as follows:

(1) the thickness of plate, (2) the diameter of the roller, (3) the kind of material, and (4) the heat treatment to which the material was subjected.

All specimens were plates having solid rectangular sections and all plates were four inches wide and twelve inches long. The plates varied in thickness from 0.25 inches to four inches; the rollers varied in diameter from 116 inches to 476 inches. Most of the plates were steel castings of medium grade but a number were hot rolled steel of structural grade and two were manganese steel castings. Most of the specimens were annealed before being tested but a few were hardened by heat treatment.

2. **Acknowledgments.** This report is substantially the same as a forthcoming Bulletin of the Engineering Experiment Station of the University of Illinois.[1] The tests were made by the Engineering Experiment Station working in consultation with the Special Committee on the Bearing Value of Large Rollers. The American Bridge Company, Strobel Steel Construction Company, and the American Steel Foundries made extensive contributions of materials. The Scherzer Rolling Bascule Bridge Company contributed $500.00 and the American Railway Association contributed $2500.00 toward the work of the Committee.

The investigation was made as a part of the work of the Engineering Experiment Station of the University of Illinois, of which Dean M. S. Ketchum is the Director, and of the Department of Civil Engineering, of which Professor W. C. Huntington is the head. Most of the tests were made by Marshall Holt and R. L. Moore, halftime research graduate assistants of the College of Engineering, working under the direction of the Chairman of the Committee.

(II) DESCRIPTION OF TESTS

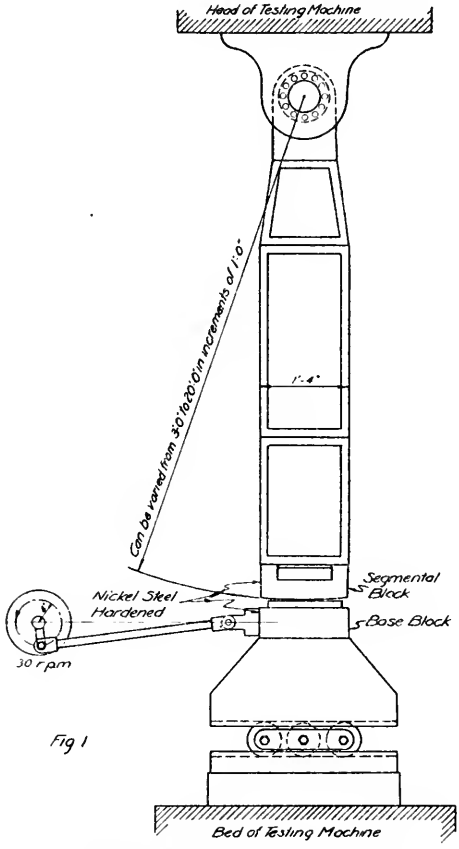
3. **Description of Apparatus.** The special apparatus that was used for the rolling tests is illustrated in Fig. 1. The specimen was rolled between two blocks, one designated as a segmental and the other as a base block. The segmental block was suspended from the radius arm that was pivoted at the upper end in the large roller bearing suspended from the head of the testing machine. The base block was supported on a roller carriage resting on the bed of the testing machine. The carriage was rolled back and forth by means of a motor-driven crank having a velocity of 30 revolutions per minute and a stroke of eight inches. The axis of the cylindrical surface of the segmental block coincided with the axis of the roller bearing so that, with perfectly true surfaces, the carriage could be rolled back and forth without changing the pressure on the specimen. Actually, the change in pressure was not great.

The segmental and base blocks were made of nickel steel and were hardened so they would not suffer permanent deformation during the tests. Since the modulus of elasticity is not materially different for hardened nickel steel and other grades of softer steel, the use of the hardened blocks should not materially affect the results of the tests. The upper surface of the base block was ground until it would prove up with a surface plate. The cylindrical surface was ground by swinging the segmental block about the roller bearing and across the face of a grinding

[1] Bulletin 191, Engineering Experiment Station, University of Illinois. This Bulletin may be obtained by addressing the Director of the Engineering Experiment Station, Urbana, Illinois.

wheel when the segmental block had been attached to the radius arm, thus assuring a true cylindrical surface whose axis coincided with the axis of the roller bearing. The specimens were machined in a shaper and finished by hand with a file and emery cloth.

After a specimen had been placed on the base block and the head of the machine had been lowered so as to produce pressure on the specimen,



Machine Used For Rolling Tests of Plates

thickness gages were inserted between the specimen and the segmental block, one on each side of the area in contact. If the thickness gages were parallel the pressure was considered to be uniformly distributed across the face of the segment; if they were not parallel the load was removed and shims were inserted under the carriage base and the pressure distribution was again checked with the thickness gages, adjustment being made until a satisfactory pressure distribution had been obtained.

4. **Description of Specimens.** All specimens were plates having solid rectangular sections and all were 4 inches wide and 12 inches long. The chemical composition of the material is given in Table 1 and the physical properties are given in Table 8.

Specimens A, B, D, E and F are all medium grade steel castings donated by the American Bridge Company and the castings from which all of these specimens were cut were poured from the same heat. The original castings were large enough so that, after being machined on all sides, they were rectangular parallelopipeds four inches by twelve inches by thirty-six inches. Specimens were obtained by making a cut across the blocks with a hacksaw, thereby getting rectangular plates 4 inches by 12 inches and having any desired thickness. All specimens designated by the same letter were cut from the same block. The castings were annealed by the foundry and again after they were received at the laboratory. The laboratory furnace was so small that it could not take a whole block and each was cut into two nearly equal pieces that were annealed separately. The individual specimens were sawed from these pieces after they had been annealed. Unfortunately, no record was made of the plates that were annealed simultaneously except for the F specimen, for the latter, F1 to F11 inclusive were annealed together. A chemical analysis of casting E gave the following results: carbon 0.283, sulphur 0.043, silicon 0.046, and manganese 0.496. Since A, B, D, and F, were poured from the same heat they had substantially the same composition. In the laboratory annealing, the castings were held at a temperature of approximately 1670 degrees Fahr. for about 3 hours and then were allowed to cool in the furnace.

Castings C41 and C42 were medium grade steel castings donated by the American Steel Foundries and the test bars representing heats from which the specimens were poured had the following analysis: carbon 0.30; sulphur 0.035; silicon 0.35; phosphorus 0.020; and manganese 0.70. Each of these specimens was made from a separate casting, the original being large enough so that at least 0.25 inches of material was removed from each side in finishing the specimen. These castings were annealed by the foundry but were not annealed at the laboratory. The physical properties of the test bar, as reported by the foundry were: tensile strength, 82,000 pounds per square inch; yield point, 41,000 pounds per square inch; elongation in 2 inches, 25.0 per cent; and reduction of area, 45.0 per cent. Specimens cut from the plates that were subjected to the rolling tests gave the values listed in Table 8.

Specimens C41 HYL and C42 HYL were also contributed by the American Steel Foundries. They were manganese castings that are sold under the trade name of Hylastic. The chemical and physical properties determined from test bars, as reported by the foundry are: carbon 0.35; sulphur 0.03; silicon 0.40; phosphorus 0.02; and manganese 1.45; tensile strength, 109,000 pounds per square inch; yield point, 63,000 pounds per square inch; elongation in 2 inches, 22.0 per cent; and reduction in area, 45.0 per cent. Specimens cut from plates that had been subjected to the rolling tests gave the values listed in Table 8. Each plate was made from a separate casting, the original being large enough so that at least 0.25 inches of material was removed from each side in finishing the specimen. The castings were normalized by the foundry but received no heat treatment at the laboratory.

Specimens M1 to M6 and L1 to L9, inclusive, were hot rolled steel supposedly of structural grade bought in the open market. All M specimens were cut from one bar and all were annealed in the same heat at the laboratory. The same statement is true relative to the L specimens. In annealing, the specimens were held at a temperature of 1570 degrees Fahr. for two hours and then cooled in the furnace. The original section was large enough so that 0.25 inches of metal was removed from all sides in finishing the specimens. The physical properties of the material, determined from specimens cut from the plates after they had been subjected to the rolling tests are given in Table 8.

Specimen L1A was obtained by hardening L1 after the latter had been subjected to the rolling test; the treatment consisted of holding the block at a temperature of 1575 degrees Fahr. for one and one-fourth hours, quenching in water and then drawing the temper by reheating to a temperature of 800 degrees Fahr. and holding at that temperature for approximately one hour. The specimens were refinished after heat treatment before being retested. Specimens L2A to L6A were obtained from L2 to L6, respectively, in a similar manner.

5. **Description of Tests.** The object of the tests was to determine the load that would produce a permanent deformation of the plate. The longitudinal and transverse deformations were both measured, the former with a 2-inch strain gage and the latter with a micrometer. Fig. 2 shows the strain gage holes and micrometer plugs in a specimen. Longitudinal deformation was measured on both edges of a plate and both longitudinal and transverse deformation were read at the top, mid-height, and bottom, except in the case of thin plates.

Specimen Showing Strain Gage Holes
And Micrometer Plugs

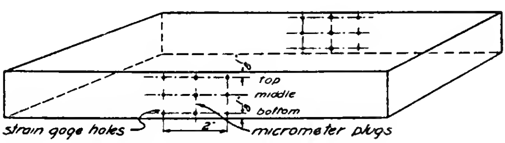


Figure 2

The method of conducting a test was as follows: A complete set of strain gage and micrometer readings was taken before the plate was loaded. The plate was then rolled under the first load and a complete set of readings taken at the end of 500, 1,000 and 2,000 strokes, the load being removed before the readings were taken in each case. The first load at which the plate was rolled was so small that no permanent deformation was expected. After a run of 2,000 strokes had been completed, the load was increased and another run of 2,000 strokes was made. Runs were thus made at successively increasing loads until a large deformation had been produced, strain readings being taken at the end of 500, 1,000 and 2,000 strokes at each load. The effect of rolling at various loads was determined by drawing a diagram showing the relation between load and permanent deformation.

The object of taking strain readings at the end of 500, 1,000 and 2,000 strokes was to determine whether the permanent deformation at a given load was all produced during the first few strokes at that load or whether the deformation was continuous for a large number of strokes. In plotting the load-deformation diagrams, the deformation that was used was the deformation at the end of 2,000 strokes. Fig. 3 shows the load-deformation curves for a 1.5-inch plate made of annealed steel casting of medium grade when rolled under a 356-inch roller, Figure 3a giving the longitudinal and Fig. 3b the transverse or lateral deformation. The deformation at the top, at the bottom, and the average deformation over the entire depth of the plate are plotted separately. In these, and all other similar diagrams of this report, the load is in pounds per inch width of plate and the deformation is in thousandths of inches per inch. From the standpoint of ease of interpretation, these are satisfactory diagrams in that they contain a decisive "break" and the minimum load at which further increase in the load produces a rapid increase in the deformation can be quite definitely located. But, although Fig. 3 shows the results of an actual test, other tests do not give such satisfactory diagrams. If the plate is either too thick or too thin relative to the diameter of the roller, the two arms of the diagram are connected with a wide instead of a sharp curve. Moreover, the flow at the top and bottom differ greatly in deep plates, whereas, in Fig. 3, the deformation is practically the same at all depths, although there was a slight longitudinal deformation at the bottom before any occurred at the top. This is a common phenomenon even for medium and thin plates.

(III) RESULTS OF TESTS

6. **Criterion for Determining Load that should Govern the Design of Sole Plates.** The relation between the load and the permanent deformation of a specimen is shown by the diagrams of Fig. 3. If a load-deformation diagram contains a sharp break, this break corresponds to the smallest load at which further increase in the load will produce a large increase in the deformation. This may be considered as a critical load and one that should govern the working load in the design of a structure. Some load-deformation diagrams do not, however, contain a very sharp break. Moreover, for thin plates, longitudinal flow takes place under a smaller load at the bottom than at the top of the plate; for a thick plate the reverse is true. There is a question whether localized flow, that which occurs only at the top or the bottom and does not extend through the plate, is injurious. With these facts in mind, four criteria dependent

upon longitudinal flow were considered for determining the load that should govern design. These are:

(a) Load that produced a flow of 0.001 inches per inch at point where flow first occurred.

(b) Load that produced an average flow over the entire depth of 0.001 inches per inch.

(c) Load corresponding to the break in the diagram showing the flow at the point where flow first occurred.

(d) Load corresponding to the break in the diagram showing the average flow over the entire depth.

The flow used in these methods is the flow in 2,000 strokes.

The critical load determined by methods a, b, c, and d, are indicated in Fig. 3 by the corresponding letters.

Methods a and c are based upon the assumption that the load producing localized flow, either at the top or the bottom of the plates, should govern; methods b and d are based upon the opposite assumption that the load producing a flow throughout the depth of the plate should govern. Methods a and b were devised primarily to interpret diagrams that do not contain a sharp break whereas c and d are especially applicable to diagrams that do contain a sharp break, but they can, however, be used on other diagrams. Lateral flow does not penetrate to the bottom of thick plates until a large flow has taken place at the top. For this reason methods b and d did not seem suitable for determining a critical load from the lateral flow. The critical load, as it is called, was determined from the longitudinal and lateral flow by these various methods and the results for a large number of tests are tabulated in Tables 2 to 6. An inspection of these tables indicates that, considering only the longitudinal flow, the values of the critical load determined by the four methods are in substantial agreement in most cases. Likewise, considering only the lateral flow, the values of the critical load determined by the two methods are in substantial agreement in most cases. The interpretation of the results would therefore not seem to be materially affected by the criterion selected for determining the critical load. Of the various methods considered, method c seemed to be the most satisfactory and it is the one that has been used in analyzing the results of the tests. The term "critical load" will therefore be used to designate the load corresponding to the break in the curve showing the relation between load and flow, at the point, top or bottom, where flow first occurs. One critical load has been determined from the longitudinal and another from the lateral flow. Since methods a and c give roughly the same results, a plate that is rolled 2,000 strokes under a critical load, will suffer a flow of approximately 0.001 inches per inch, which, also approximately, equals the elastic deformation at the elastic limit of structural steel and steel castings of medium grade.

The design load should be governed by the critical load, the proper ratio of the design to the critical load being a matter of judgment.

7. **Characteristics of Plastic Flow.** Consideration of plastic flow will be limited to a very general consideration of a few of the phenomena.

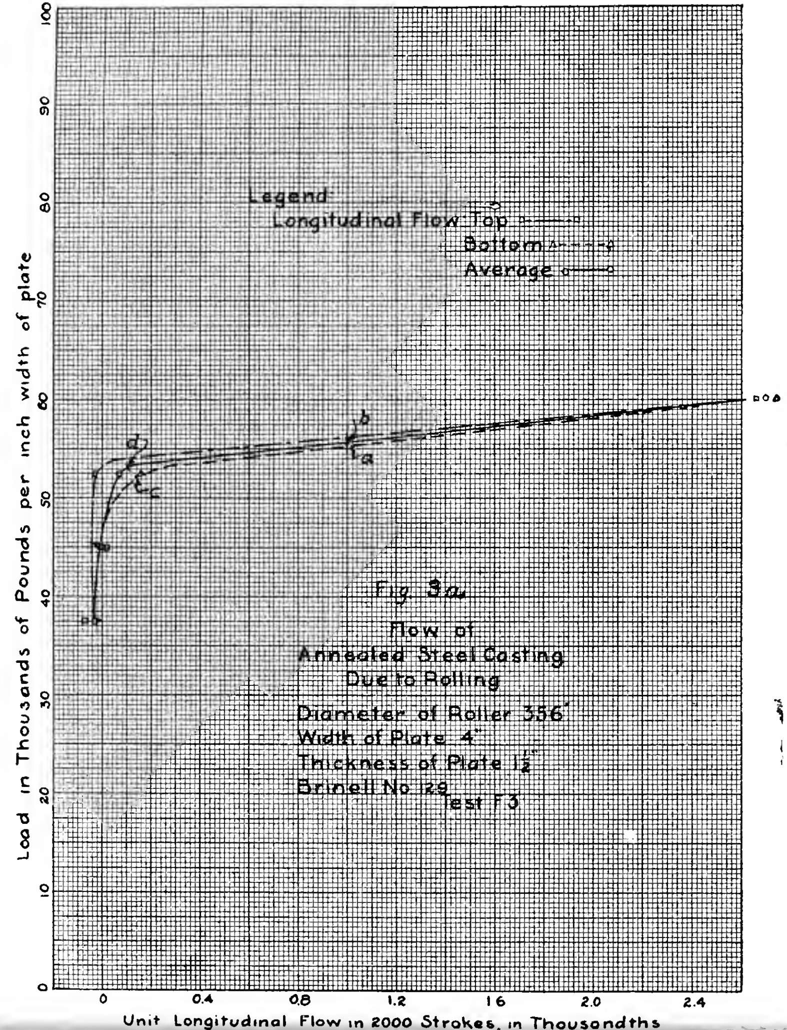


Fig. 3a
Flow of
Annealed Steel Casting
Due to Rolling
Diameter of Roller 3.56"
Width of Plate 4"
Thickness of Plate 1½"
Brinell No 129
Test F3

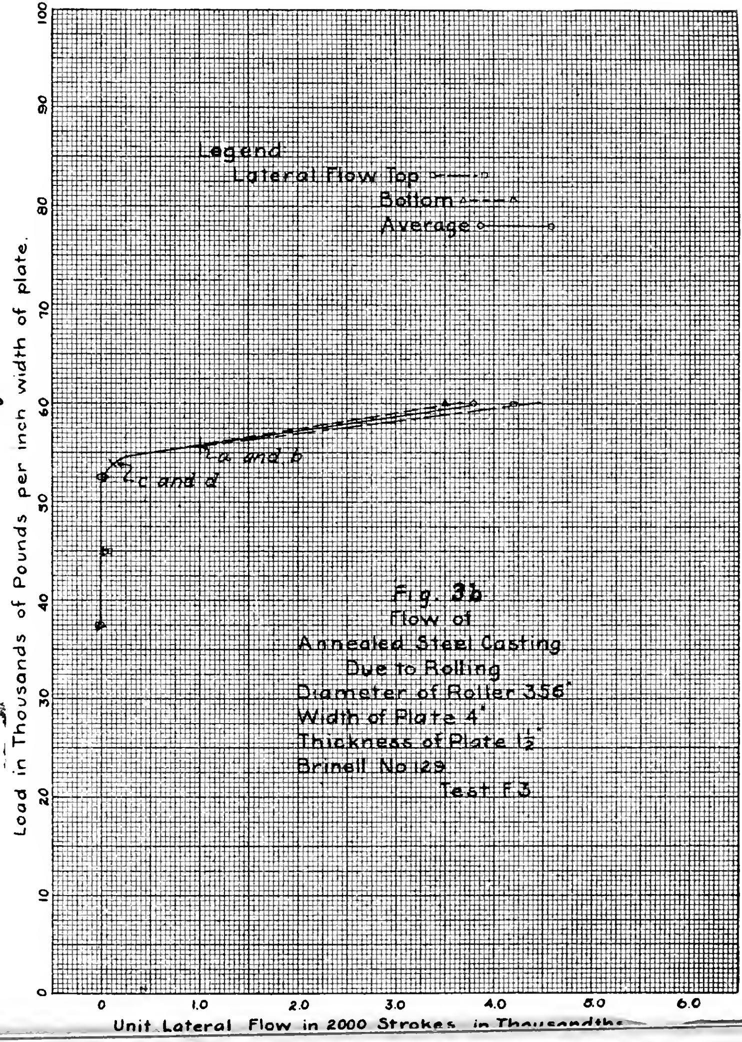


Fig. 3b
Flow of
Annealed Steel Casting
Due to Rolling
Diameter of Roller 3.56"
Width of Plate 4"
Thickness of Plate 1½"
Brinell No 129
Test F3

A perfect liquid has been defined as a substance having zero resistance to shear. If a plunger is pressed down on the surface, the liquid flows freely in all directions and the downward pressure on the plunger equals the hydrostatic pressure upward, on the bottom of the plunger. A similar plunger pressing on the surface of a solid produces a tendency for the material to flow in all directions but this tendency is resisted by the shearing resistance of the material. A small pressure will produce some deformation but this will disappear as soon as the pressure is removed, providing the elastic limit of the material has not been exceeded. If the pressure is great enough the elastic limit will be exceeded and part of the deformation will remain after the load has been removed. If the body is a cylinder having a vertical axis and having pressure uniformly distributed over the entire top and bottom horizontal surfaces, the deformation is largely a shear deformation and is quite properly defined as a flow of metal. And under the conditions described, the tendency to flow will be the same in all directions.

The effect of a loaded cylinder having its axis parallel to the plane surface upon which it rests, differs in many ways from the effect of the cylinder described in the preceding paragraph. The cylinder with axis parallel to the plane surface produces a tendency toward horizontal flow but the tendencies to flow in two directions at right angles to each other, one parallel and the other normal to the axis of the cylinder and both directions horizontal, differ because of the difference in the extension and in the shape of the bodies in contact. This difference is explained more in detail in connection with Fig. 4.

Loaded Cylinder With Axis Parallel to Plane of Support

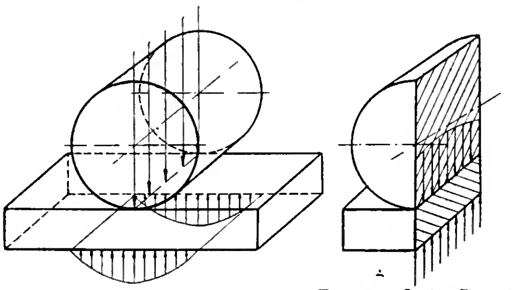


Figure 4

Flow parallel to the axis of the cylinder will be designated as lateral flow. Contact is continuous along the cylinder and a vertical plane through the axis will cut the surfaces in contact in a straight line. The conditions tending to produce lateral flow are similar, except for the influence of flow in one direction upon flow in other directions, to the conditions that would exist if the cylinder were replaced by a plate. This is apparent from the sectional view of Fig. 4. The specimen, at the vertical section through the axis of the cylinder, is subjected to a vertical pressure over its entire width at both the top and bottom so that, except for some possible variation in the distribution of the pressure, there is no flexural effect tending to produce lateral flow. The shear producing lateral flow is highly localized at or near the surfaces in contact.

The horizontal flow normal to the axis and parallel to the motion of the rolling cylinder has been designated as longitudinal flow. The tendency to flow in this direction is affected by the shape of the bodies in contact and, in addition to the shear, there is a flexural stress due to the downward pressure being concentrated on a comparatively narrow transverse strip whereas the upward pressure is distributed over a wide strip. Inasmuch as the longitudinal flow is an extension, the flexural stress has a tendency to reduce longitudinal flow at the top and increase it at the bottom.

Records showing the distribution of the plastic flow of plates as determined experimentally are presented as information of interest. Fig. 5 shows the longitudinal flow at the top, middle and bottom of plates 1.5, 2, and 3 inches thick when rolled under a cylinder 188 inches in diameter. The flow is the unit flow, thousandths of inches per inch, in 2,000 strokes.

Fig. 5 shows that for a 188-inch roller, the longitudinal flow began at the bottom before it did at the top, for a 1.5-inch and a 2-inch plate, whereas the reverse is true for a 3-inch plate. Figures 6a and 7a show that, for a 476-inch roller, longitudinal flow began at the bottom before it did at the top for a 3-inch plate whereas the reverse was true for a 4-inch plate. The numerous tests that have been made on plates of various thicknesses and with rollers of various diameters, a few of which are reported in Fig. 5 to 8 inclusive, show that in general the longitudinal flow begins on the bottom before it does on the top for thin plates whereas the reverse is true for thick ones. Moreover, the minimum thickness of plate which will have initial longitudinal flow at the top is less for a small than for a large roller, and the governing factor seems to be the ratio of the thickness of plate to diameter of roller rather than the thickness of plate alone.

Fig. 6, 7, and 8, also show the vertical distribution of the lateral flow. In all cases the lateral flow starts much earlier at the top than at the bottom and greatest flow is at the top for all loads. Further, in all cases longitudinal flow begins at the bottom before lateral flow.

Fig. 9 shows the vertical distribution of the longitudinal deformation under static loads of various magnitudes. The plate was an annealed steel casting of medium grade, 4 inches thick and the roller was 476 inches in diameter. The deformation was measured when the plate was loaded so it is partly elastic and partly inelastic or permanent.

The deformation at the top of the plate, thus measured, is a contraction at all loads, even though some of the loads are great enough to produce a large longitudinal elongation when the plate is rolled. Further data relative to this apparent anomaly are given in Fig. 10. Curve a, represents the

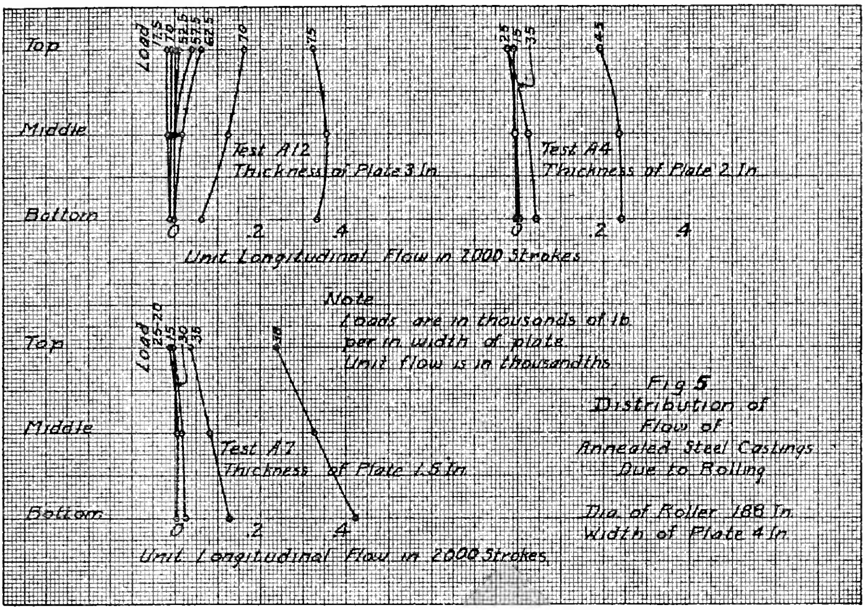


Fig 5
Distribution of Flow of Annealed Steel Castings Due to Rolling

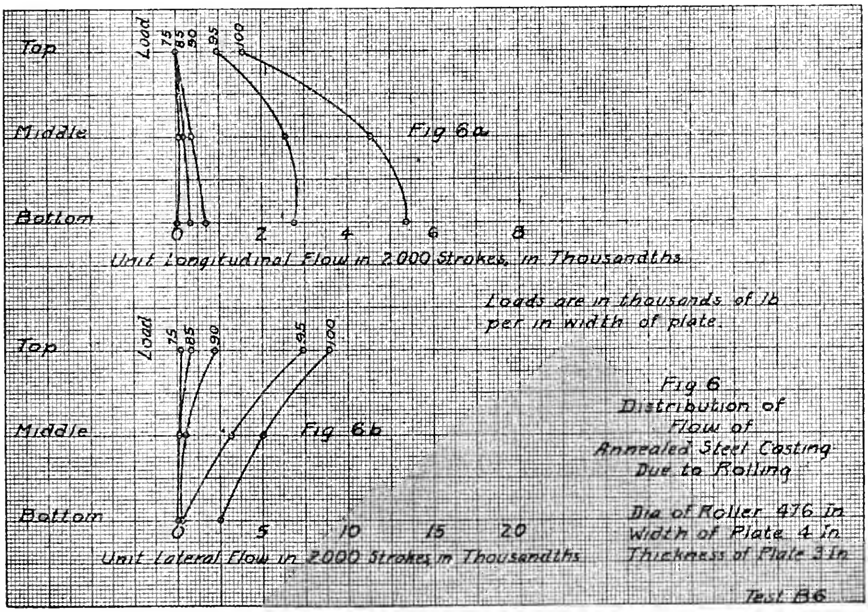
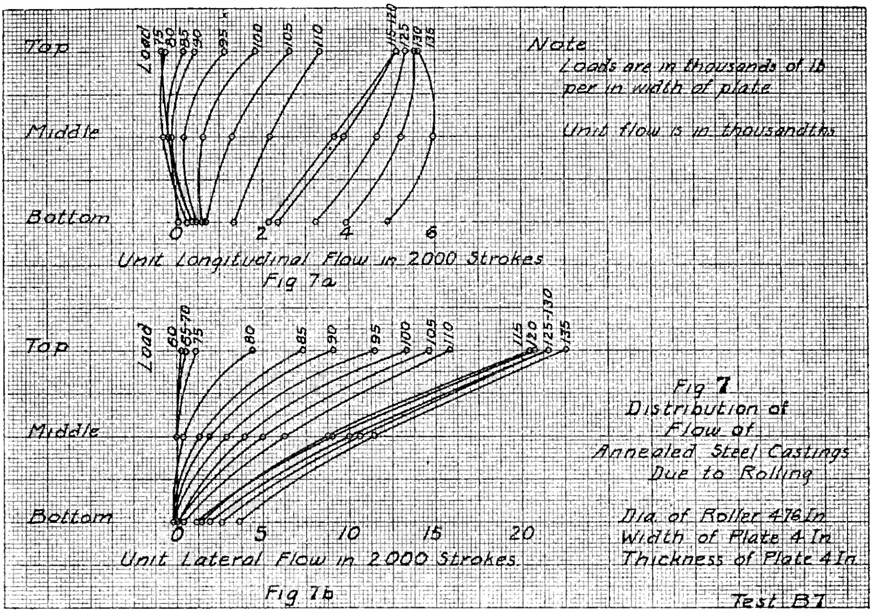
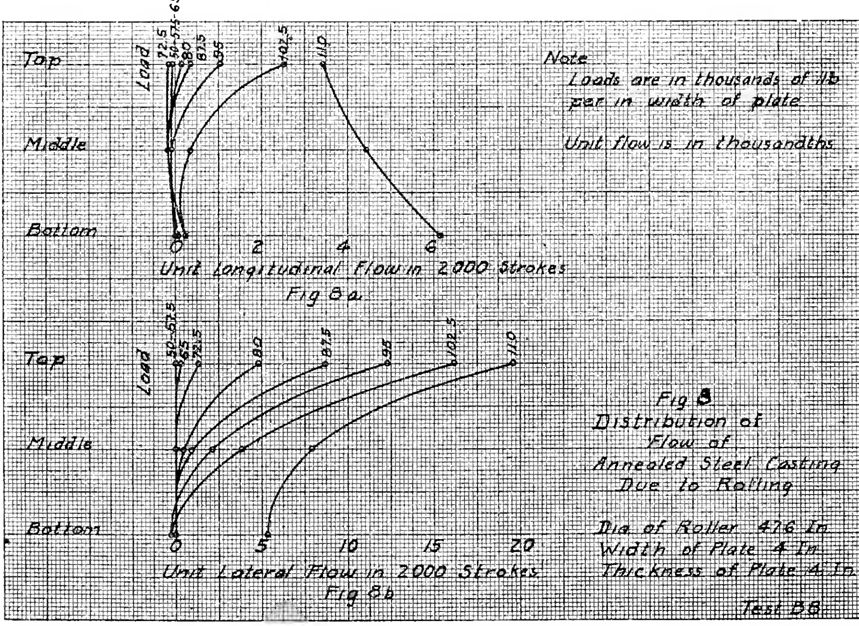


Fig 6
Distribution of Flow of Annealed Steel Casting Due to Rolling


Note
Loads are in thousands of lb per in width of plate
Unit flow is in thousandths
Top
Middle
Bottom
Load
Unit Longitudinal Flow in 2000 Strokes
Fig 7a
Unit Lateral Flow in 2000 Strokes
Fig 7b
Fig 7
Distribution of Flow of Annealed Steel Castings Due to Rolling
Dia. of Roller 4.76 In
Width of Plate 4 In
Thickness of Plate 4 In
Test B7


Note
Loads are in thousands of lb per in width of plate
Unit flow is in thousandths
Top
Middle
Bottom
Load
Unit Longitudinal Flow in 2000 Strokes
Fig 8a
Unit Lateral Flow in 2000 Strokes
Fig 8b
Fig 8
Distribution of Flow of Annealed Steel Casting Due to Rolling
Dia. of Roller 4.76 In
Width of Plate 4 In
Thickness of Plate 4 In
Test B8

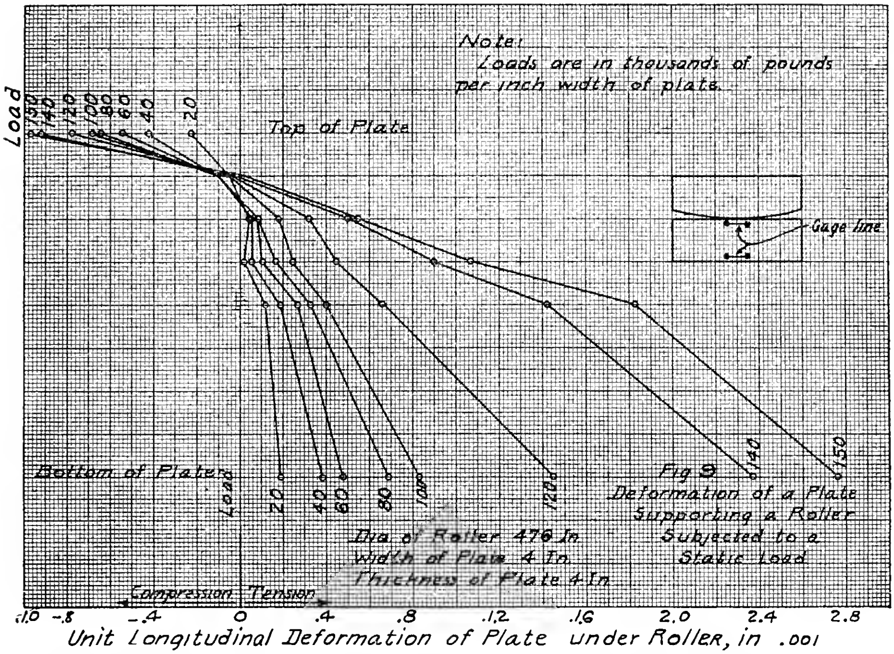


Fig 9
Deformation of a Plate Supporting a Roller Subjected to a Static Load

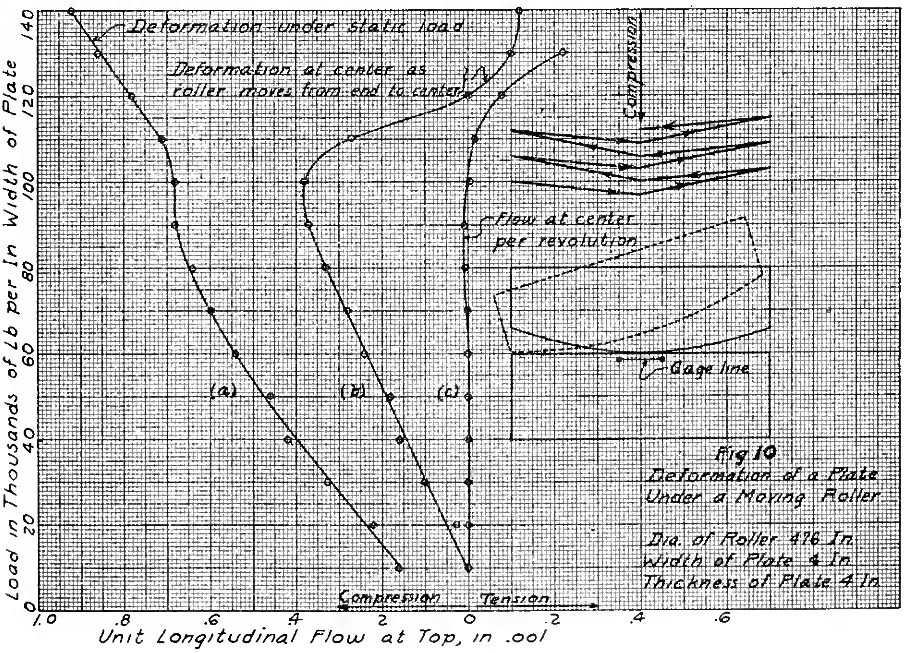


Fig 10
Deformation of a Plate Under a Moving Roller

longitudinal deformation at the top of the plate, due to a static load, measured when the load was applied. Curve b, represents the longitudinal deformation at the same point due to a rolling load, measured as the load rolled over the gage line. The deformation corresponding to the horizontal distance between curves a and b may be considered as being due to the motion of the roller. Curve c is the flow per revolution at the gage line, due to the rolling load. It is a permanent deformation since the load was removed before the readings were taken.

The curves a, b, and c, have an interesting relation at the 100,000-pound load where curve a has its curvature reversed, b has a maximum abscissa, and c passes from the negative to the positive field. That is, for this test at least, the deformation at the center as the roller moved from the end to the center, increased with the load, reached a maximum, and then decreased; and the load that produced this maximum deformation was the least load that produced a permanent longitudinal elongation. If this relation between curves b and c always existed, the construction of curve b would be an excellent means of determining a minimum load that would produce a permanent longitudinal elongation of a plate subjected to rolling.

The fact that at loads greater than 100,000 pounds, the plate elongated with rolling, although single applications of a static load contracted it, indicates that the motion of the roller as well as the load that it carried, contributed to the permanent deformation of the plate.

The permanent deformation of a plate rolled under a large roller partakes more of the character of a plastic flow than of elastic deformation. Moreover, the measured permanent longitudinal deformation was found to be opposite in sense to the theoretical elastic deformation at the top of the plate. For, according to the elastic theory, if a cylinder lying upon a plane surface is subjected to a pressure so small that the elastic limit of the material at the point of contact is not exceeded, there will be a longitudinal contraction at the top of the plate. Numerous tests verify this theory. But numerous tests also show that when a plate is rolled under a cylinder, if the pressure is increased sufficiently, the longitudinal flow is an extension. In other words, the sense of the permanent deformation of a rolled plate is opposite to the sense of the elastic deformation under a roller subjected to a static load. Further, the sense of the permanent deformation of a plate rolled under a large load is opposite to the sense of the elastic deformation of the same plate rolled under a smaller load.

Apparently the mathematical theory of elasticity, although correct when the assumptions upon which it is based are complied with, is not applicable to the plastic flow that occurs when a plate is rolled.

The flow of metal that occurs when a plate is rolled is due largely to the breaking down of resistance to shear and the flow is normal to the line of action of the external force causing the flow. Under these conditions slight variations in the physical properties of the material will cause a considerable variation in the load required to produce flow and may even cause a considerable variation in the character of the flow. The same degree of consistency cannot, therefore, be expected in rolling tests that is obtained in simpler tests such as those made on standard tension specimens.

The relation between the load and the deformation of a plate is shown in Fig. 3 for a 1.5-inch plate rolled under a 356-inch cylinder. The deformation represented in this diagram is the deformation that occurred in 2,000 strokes at each load. Readings were taken at the end of 500, 1,000, and 2,000 strokes to determine whether all of the deformation at a given load occurred during the first few strokes or continued as long as the plate was rolled. The relation between the flow and the number of strokes is shown in Fig. 11. Data similar to those represented were obtained during a large number of tests. In a few cases flow occurred during the first thousand strokes but did not occur during the last thousand, in a few the flow was greater during the second than during the first thousand strokes, but the results represented by the diagrams of Fig. 11 are typical of the results obtained in most of the tests. These diagrams show that in general, the rate of flow is greater during the first than during the second thousand strokes, but they also show that if there is an appreciable flow during the first thousand strokes there is also an appreciable flow during the second thousand. It would therefore seem that if an appreciable flow occurs in two thousand strokes, continuous rolling at the same load is likely eventually to injure the plate.

There is considerable variation in the character of the load-deformation diagrams. The diagram of Figure 3 is typical of many that were obtained from tests for which the ratio of thickness of plate to diameter of roller was small, thus resulting in a fairly uniform distribution of the longitudinal flow throughout the depth of the plate. Test F4, reported in Fig. 12, is a duplicate of F3, reported in Fig. 3. There was a slight permanent contraction at the top of plate F4 at the smaller loads. This contraction, though not typical, was not uncommon. The longitudinal elongation was approximately the same at all depths for thin plates but varied considerably for thick ones. Further, the elongation was quite consistent for thin plates but very erratic for thick ones. Figures 3 and 12 are typical of diagrams for thin plates, whereas Fig. 13, 14, 15, 16, and 17, show curves that were obtained from tests of thick plates. The erratic character of the latter diagrams suggest the difficulty that may be expected in getting consistent results from tests of this character. Test B7, reported in Fig. 13, gave a large lateral flow at the top of the plate at a load of 80,000 pounds and practically no lateral flow at a load of 120,000 pounds. Test 14a, Fig. 16, was as bad or worse. On the other hand, duplicate tests B3 and B6, Fig. 18 and 19, gave quite smooth diagrams and the results of the two tests are very consistent. Thick plates gave more consistent results when tested under large than under small rollers, the governing factor seeming to be the ratio of thickness to diameter rather than thickness alone.

8. **Relation Between Diameter of Roller and Load Producing Permanent Deformation.** The tests of Series F were planned especially to determine the effect of the diameter of the roller upon the load required to

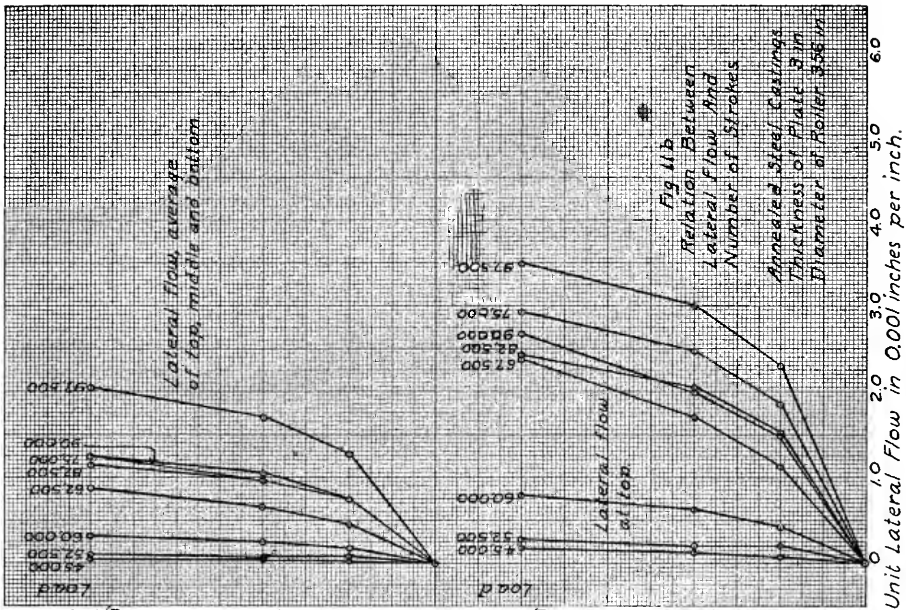


Fig 11b
Relation Between
Lateral Flow And
Number of Strokes
Annealed Steel Castings
Thickness of Plate 3 in
Diameter of Roller 3.56 in
Lateral flow, average
of top, middle and bottom
Lateral flow
at top
Load
Number of Strokes
Unit Lateral Flow in 0.001 inches per inch.

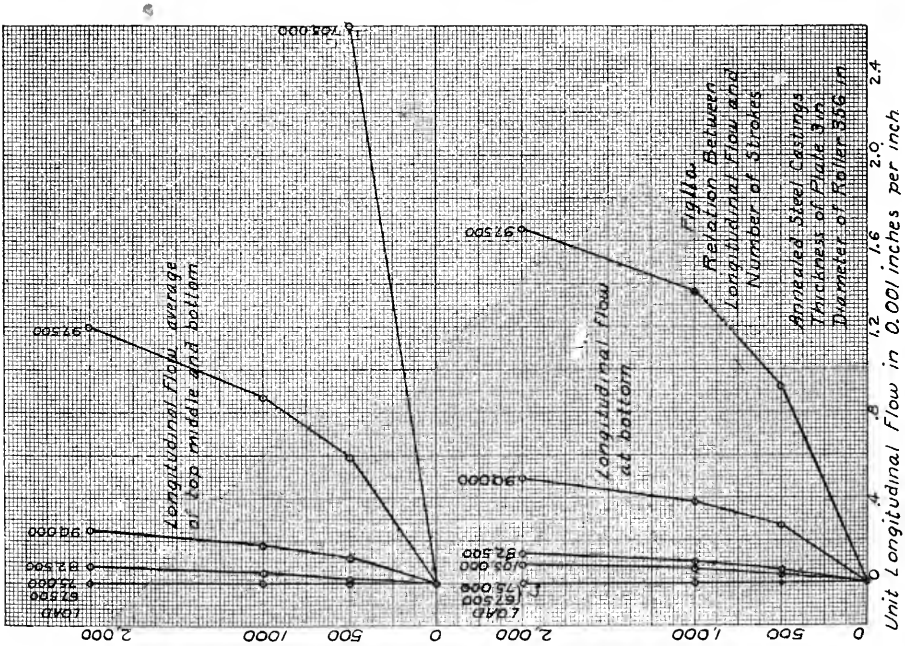
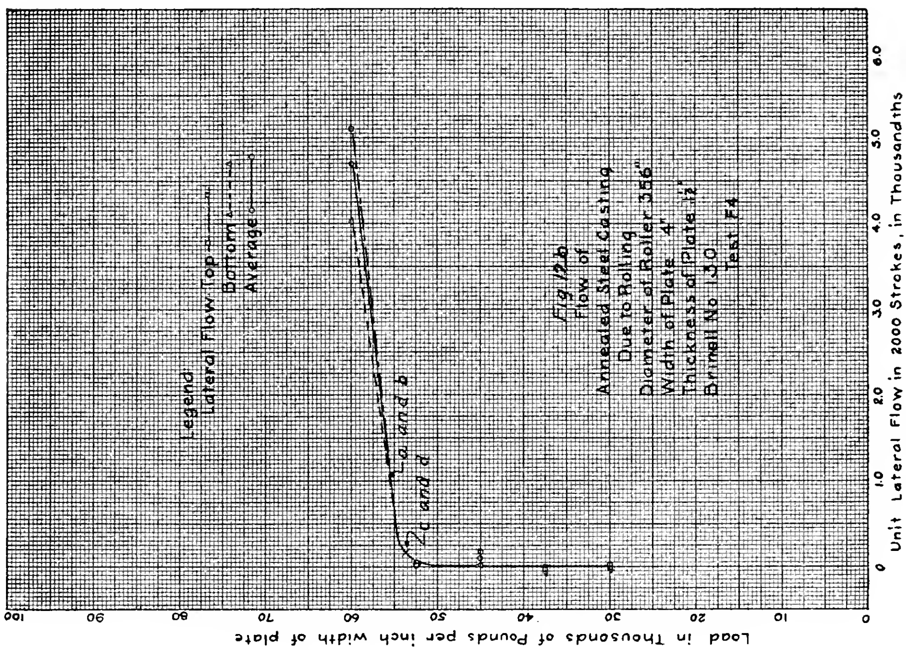
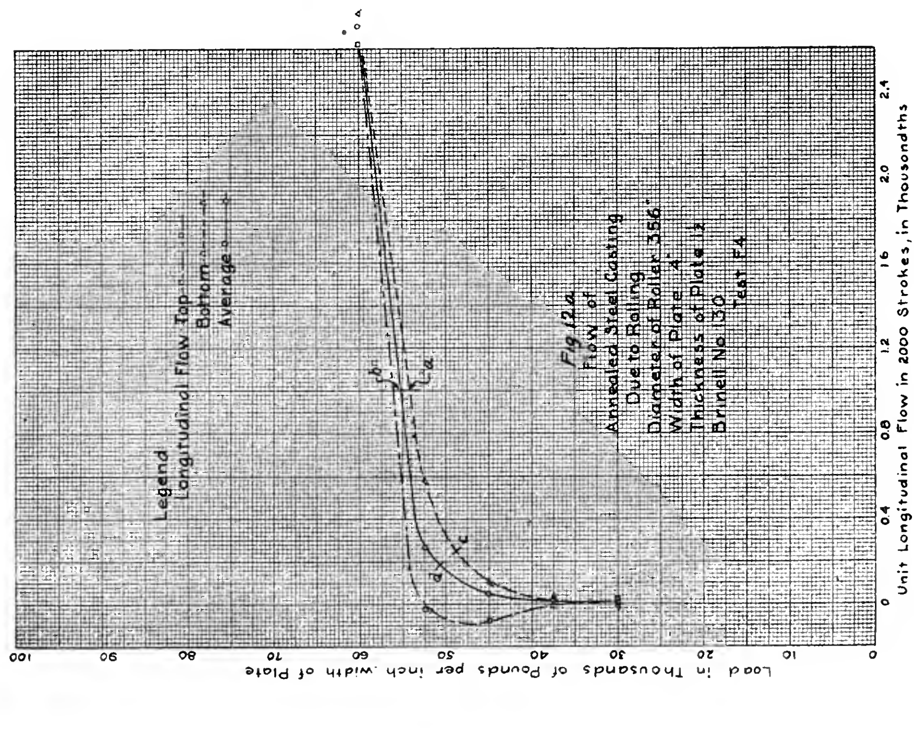
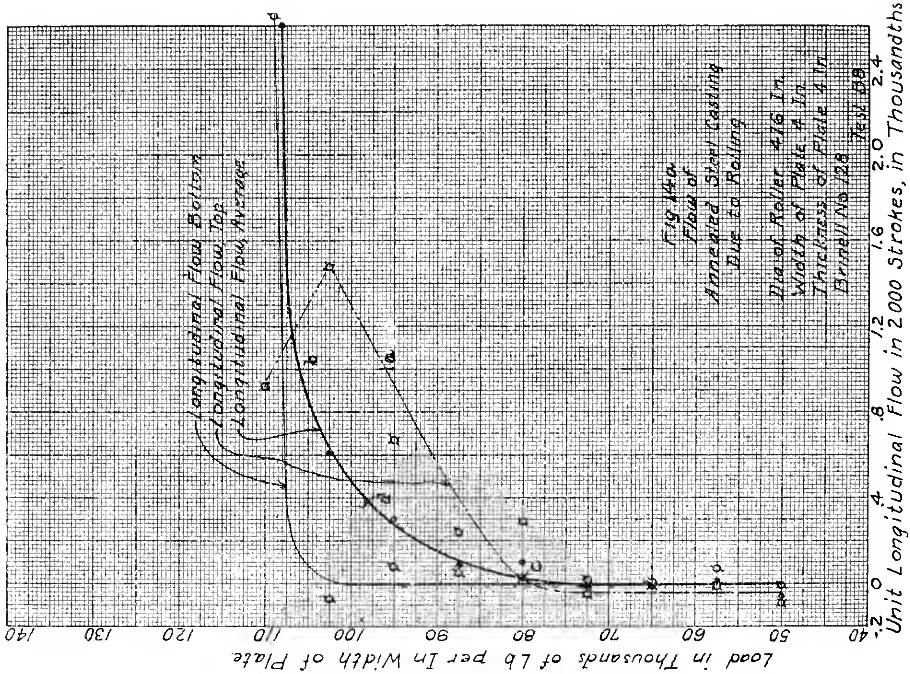
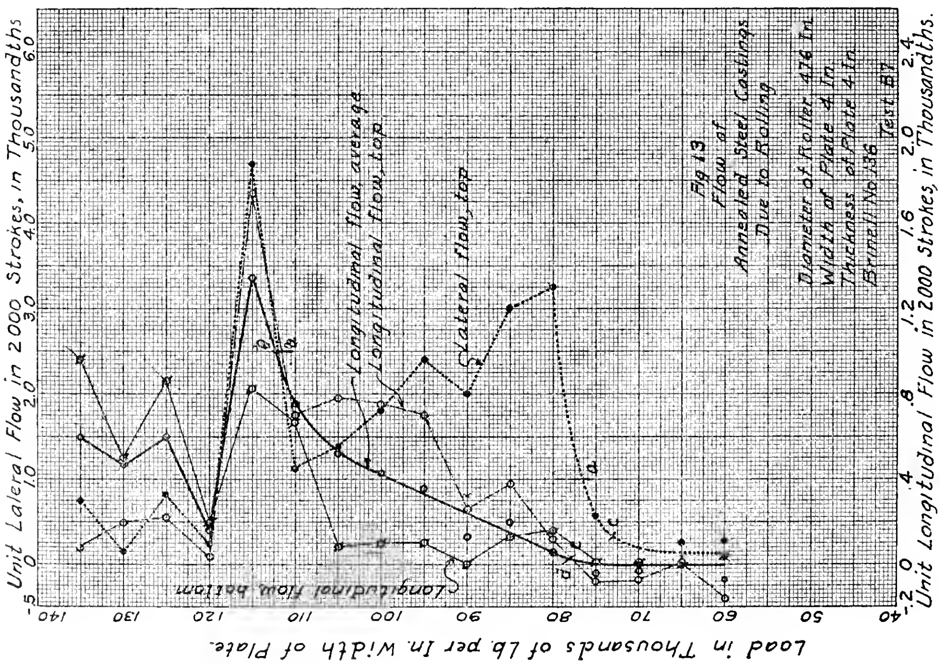


Fig 11a
Relation Between
Longitudinal Flow and
Number of Strokes
Annealed Steel Castings
Thickness of Plate 3 in
Diameter of Roller 3.56 in
Longitudinal flow average
of top middle and bottom
Longitudinal flow
at bottom
Load
Number of Strokes
Unit Longitudinal Flow in 0.001 inches per inch


Legend
Lateral Flow Top
Bottom
Average
a and b
c and d
Fig 12b
Flow of
Annealed Steel Casting
Due to Rolling
Diameter of Roller 3.56"
Width of Plate 4"
Thickness of Plate 1/2"
Brinell No 130
Test F4
Unit Lateral Flow in 2000 Strokes, in Thousandths
Load in Thousands of Pounds per inch width of plate


Legend
Longitudinal Flow Top
Bottom
Average
a
b
c
d
Fig 12a
Flow of
Annealed Steel Casting
Due to Rolling
Diameter of Roller 3.56"
Width of Plate 4"
Thickness of Plate 1/2"
Brinell No 130
Test F4
Unit Longitudinal Flow in 2000 Strokes, in Thousandths
Load in Thousands of Pounds per inch width of Plate


Longitudinal Flow Bottom
Longitudinal Flow Top
Longitudinal Flow Average
Fig 14a
Flow of
Annealed Steel Casting
Due to Rolling
Dia of Roller 4.76 In.
Width of Plate 4 In.
Thickness of Plate 4 In.
Brinell No 128
Test 88
Unit Longitudinal Flow in 2000 Strokes, in Thousandths
Load in Thousands of Lb per In Width of Plate.


Unit Lateral Flow in 2000 Strokes, in Thousandths
Longitudinal flow, average
Longitudinal flow, top
Lateral flow, top
Longitudinal flow, bottom
Fig 13
Flow of
Annealed Steel Castings
Due to Rolling
Diameter of Roller 4.76 In.
Width of Plate 4 In.
Thickness of Plate 4 In.
Brinell No 136
Test 87
Unit Longitudinal Flow in 2000 Strokes, in Thousandths.
Load in Thousands of Lb. per In. Width of Plate.

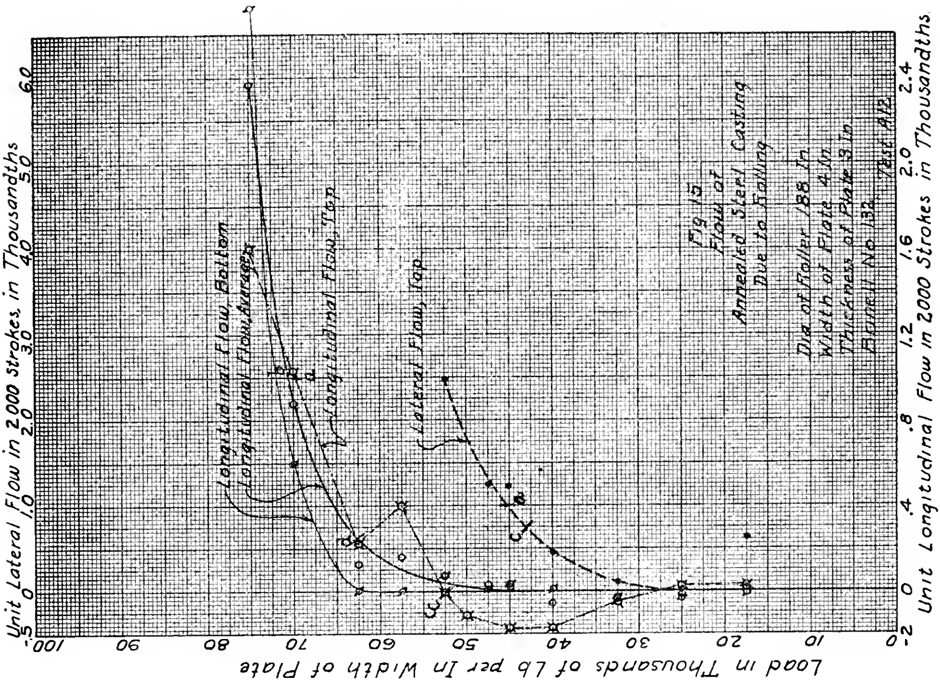


Fig 15
Flow of
Annealed Steel Casting
Due to Rolling
Dia of Roller 1.88 In
Width of Plate 4 In
Thickness of Plate 3 In
Brinell No 132
Test A12
Longitudinal Flow, Bottom
Longitudinal Flow, Average
Longitudinal Flow, Top
Lateral Flow, Top
Unit Lateral Flow in 2000 Strokes, in Thousandths
Unit Longitudinal Flow in 2000 Strokes in Thousandths
Load in Thousands of Lb per In Width of Plate

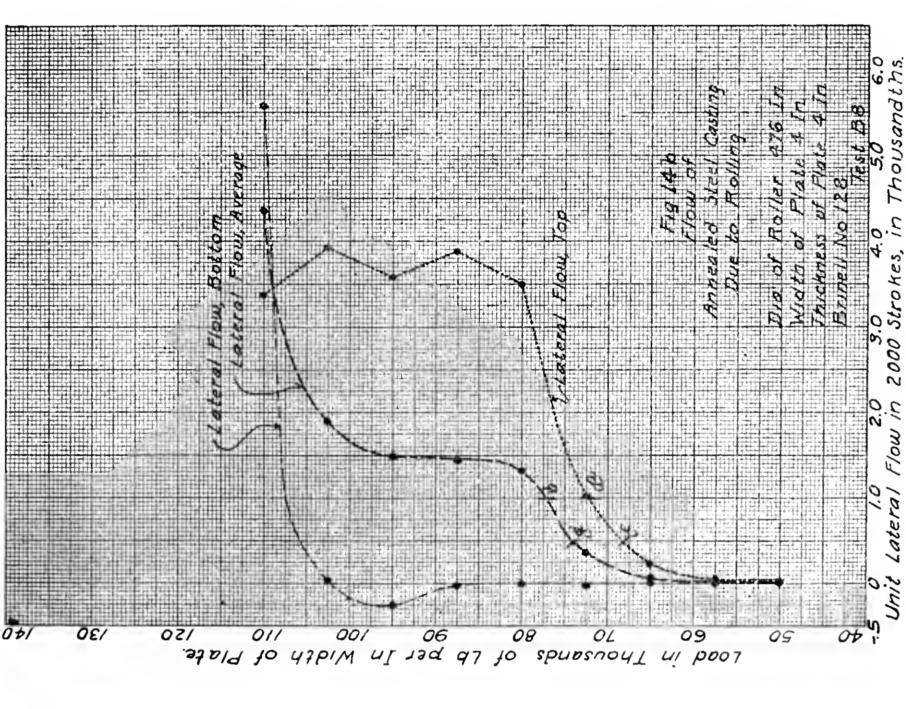


Fig 14b
Flow of
Annealed Steel Casting
Due to Rolling
Dia of Roller 4.76 In
Width of Plate 4 In
Thickness of Plate 4 In
Brinell No 128
Test B8
Lateral Flow, Bottom
Lateral Flow, Average
Lateral Flow, Top
Unit Lateral Flow in 2000 Strokes, in Thousandths.
Load in Thousands of Lb per In Width of Plate.

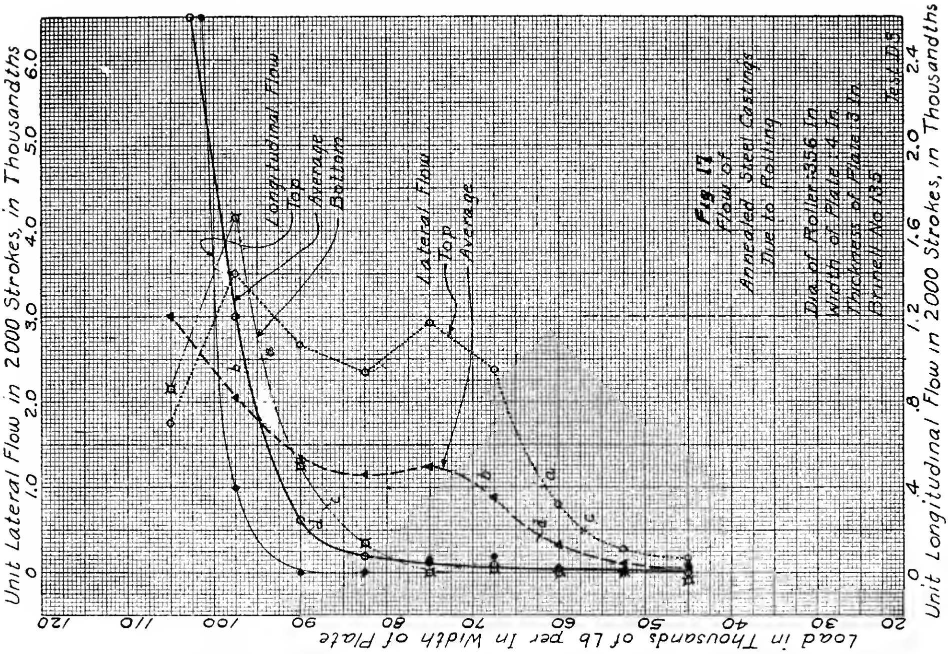
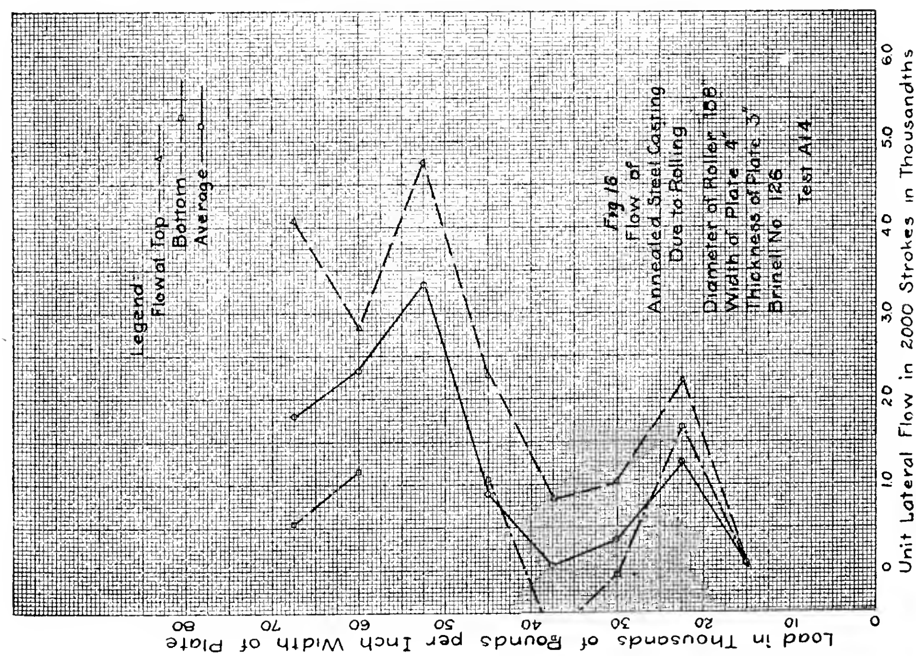
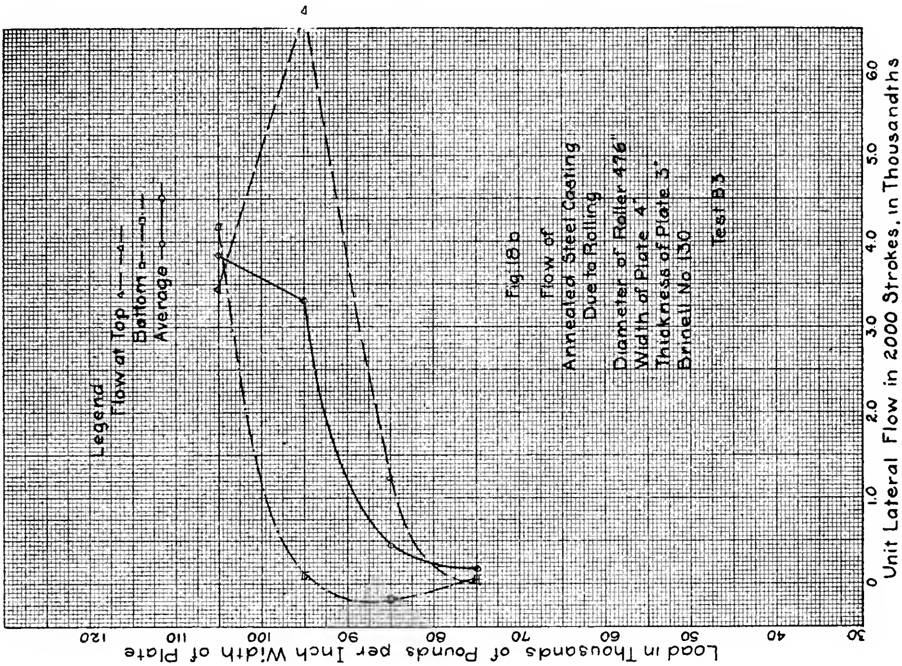
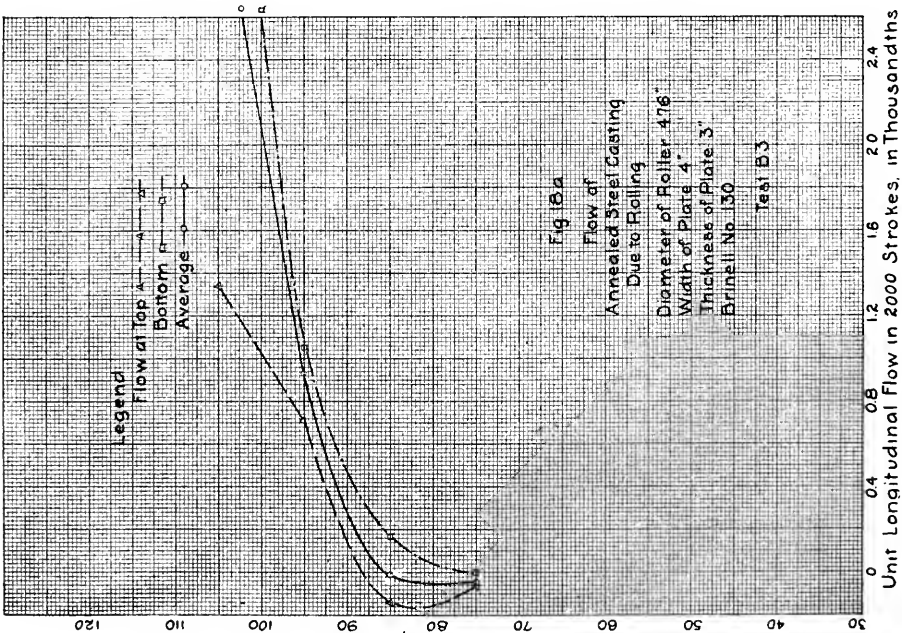


Fig 17
Flow of
Annealed Steel Castings
Due to Rolling
Dia. of Roller 3.56 In
Width of Plate 4 In
Thickness of Plate 3 In
Brinell No 135
Test D5
Longitudinal Flow
Top
Average
Bottom
Lateral Flow
Top
Average
Unit Lateral Flow in 2000 Strokes, in Thousandths
Unit Longitudinal Flow in 2000 Strokes, in Thousandths
Load in Thousands of Lb per In Width of Plate


Legend
Flow at Top
Bottom
Average
Fig 16
Flow of
Annealed Steel Casting
Due to Rolling
Diameter of Roller 1.58"
Width of Plate 4"
Thickness of Plate 3"
Brinell No 126
Test A14
Unit Lateral Flow in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate


Legend
Flow at Top
Bottom
Average
Fig 18 b
Flow of
Annealed Steel Casting
Due to Rolling
Diameter of Roller 4.76"
Width of Plate 4"
Thickness of Plate 3"
Brinell No 130
Test B3
Unit Lateral Flow in 2000 Strokes, in Thousandths
Load in Thousands of Pounds per Inch Width of Plate


Legend
Flow at Top
Bottom
Average
Fig 18 a
Flow of
Annealed Steel Casting
Due to Rolling
Diameter of Roller 4.76"
Width of Plate 4"
Thickness of Plate 3"
Brinell No 130
Test B3
Unit Longitudinal Flow in 2000 Strokes, in Thousandths
Load in Thousands of Pounds per Inch Width of Plate

produce a permanent deformation of the material in the plate. Rollers of various diameters were used in Series A, B, D, E, and M but the plates used under rollers of different diameters were annealed separately and, since a slight variation in the heat treatment causes a considerable variation in the results of the rolling tests, these series could not be used in the study of the influence of the diameter of the roller.

The specimens used in Series F were cut from a casting after it had been annealed so that all specimens used in this series received the same heat treatment. All specimens were annealed steel castings of medium grade. Four plates were tested under rollers 476 inches in diameter and two plates each were tested under rollers having diameters of 356 inches, 236 inches, and 116 inches. The critical load was taken as the load corresponding to the break in the curve showing the flow at the point where flow first occurred, designated in Section 6 as Method c. Two critical loads were determined, one from the longitudinal and the other from the lateral flow.

The relation between the diameter of the roller and the critical load as determined from the longitudinal flow is shown in Fig. 20. The results of the various tests are quite consistent and they indicate that the minimum load producing longitudinal flow increases rapidly with the diameter of the roller, the equation representing the relation between the two quantities being $P = 22{,}000 + 87D$, the equation of a straight line. It should be noted, however, that all plates had the same thickness. Moreover, if 1.5-inch plates had been tested under smaller rollers the relation of the thickness of plate to diameter of roller would have been so great that there would have been highly localized stresses at the surfaces in contact and free longitudinal flow probably would not have taken place. Because of the difference in character of the flow under large and small rollers, the diagram of Fig. 20 cannot be extended to the left. The tests were purposely limited to that field in which free longitudinal flow would take place.

The relation between the diameter of the roller and the critical load as determined from the lateral flow is shown in Fig. 21. This relation is represented by the expression $P = 20{,}000 + 97D$, the equation of a straight line. This diagram cannot be safely extended beyond the range of the tests.

9. **Relation Between Thickness of Plate and Load Required to Produce Permanent Deformation.**—Series A, B, D, E, and M were planned especially to determine the effect of the thickness of plate upon the load required to produce permanent deformation. The specimens for the first four series were annealed steel castings of medium grade and for the last one they were hot rolled steel of structural grade that had been annealed. The diameters of roller used for the series A, B, D, E, and M were 188, 476, 356, 116, and 356 inches respectively. The critical loads for the plates of various thicknesses determined by the six methods described in Section 6, page 1032, are given in Tables 2 to 6 inclusive.

The relation between the thickness of plate and the critical load is given in Fig. 22 to 26 inclusive. The upper diagram in each figure represents the critical load as determined from the longitudinal flow, and the

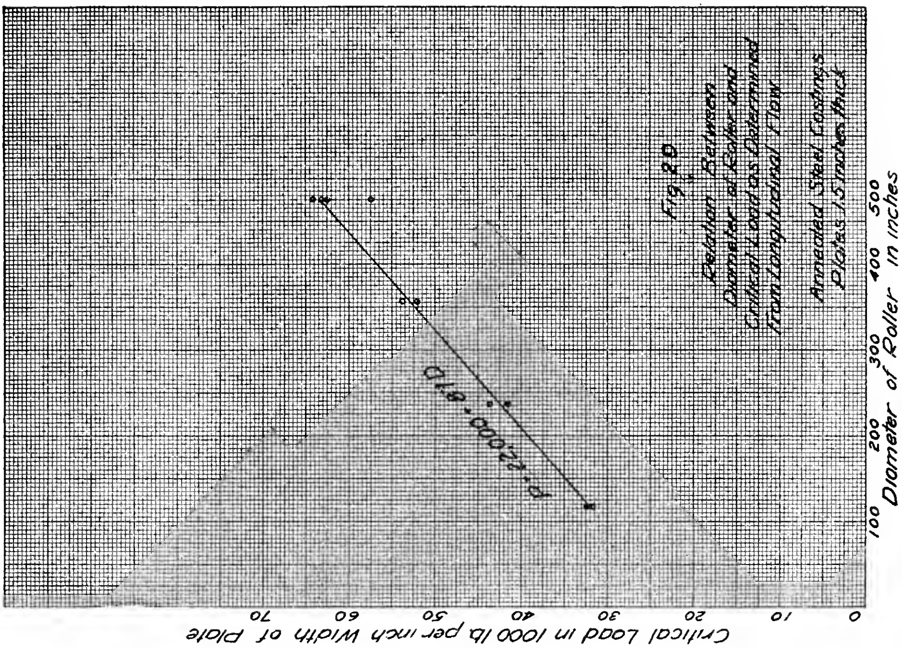


Fig. 20
Relation Between Diameter of Roller and Critical Load as Determined From Longitudinal Flow
Annealed Steel Castings
Plates 1.5 inches thick
Diameter of Roller in inches
Critical Load in 1000 lb. per inch Width of Plate

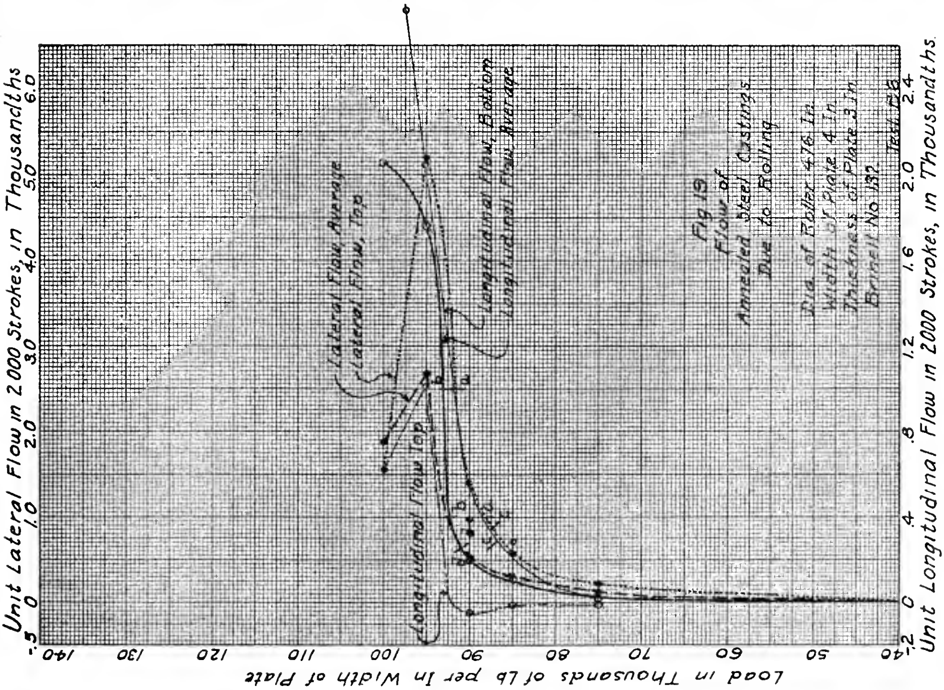


Fig 19
Flow of Annealed Steel Castings Due to Rolling
Lateral Flow, Average
Lateral Flow, Top
Longitudinal Flow, Bottom
Longitudinal Flow Average
Longitudinal Flow Top
Unit Lateral Flow in 2000 Strokes, in Thousandths
Unit Longitudinal Flow in 2000 Strokes, in Thousandths
Load in Thousands of Lb per In Width of Plate

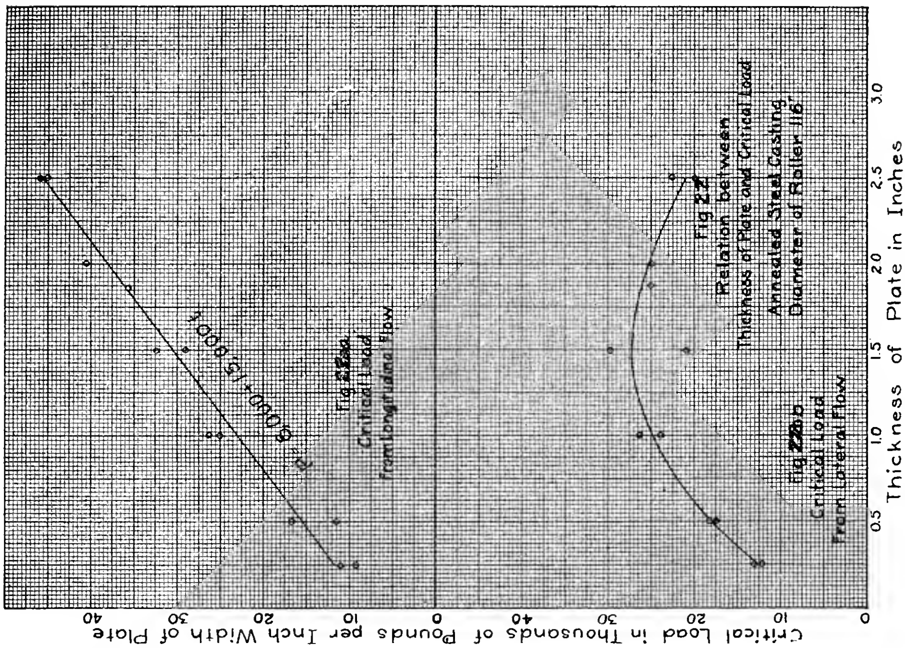
lower one as determined from the lateral flow, the critical load being determined by Method c in both cases.

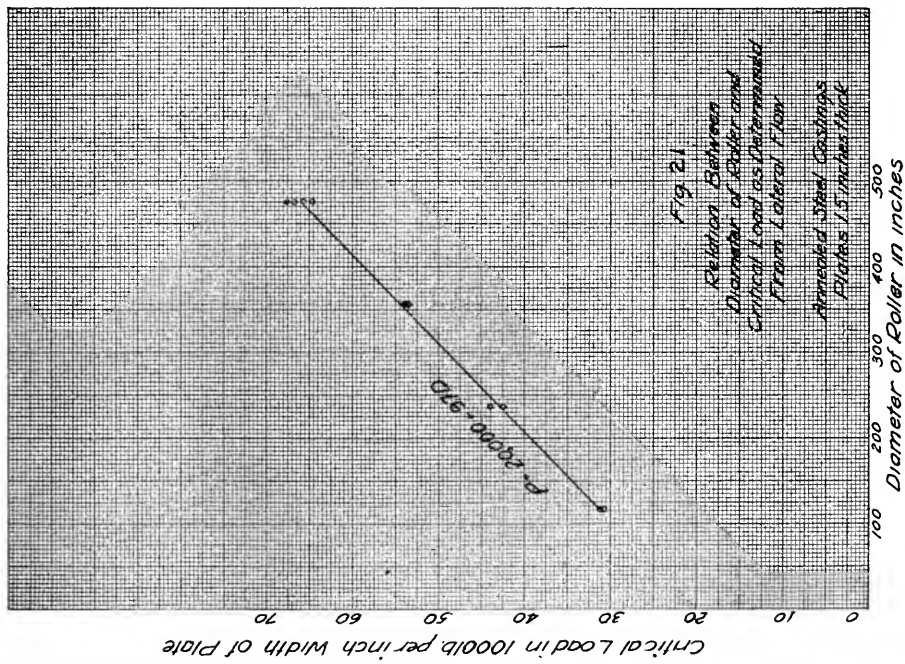
The critical load as determined from the longitudinal flow increases with the thickness of the plate and, within the limits of these tests, the relation between the two variables is well represented by a straight line. Further, the results are very consistent considering the nature of the tests. The only inconsistency is the results of the tests of 4-inch plates rolled under 476-inch cylinders. The load-deformation diagrams for the test B8, the test of one of the 4-inch plates given in Fig. 14a, shows that for this plate the longitudinal flow began at the top before it did at the bottom, the opposite in sequence to the behavior of thinner plates. If the critical load had been determined from the diagram for the longitudinal flow at the bottom instead of at the point, top or bottom, where flow first occurred, the critical load would have been 105,000 pounds instead of the 80,300 pounds given in Table 4. Likewise for Test B7, reported in Fig. 13, if the critical load had been determined from the longitudinal flow at the bottom instead of at the point where flow first occurred, it would have been 105,000 pounds instead of the 90,000 pounds given in Table 4. From this we may conclude that the critical load determined from the longitudinal flow increases with the thickness of plate so long as longitudinal flow first begins at the bottom, but when the thickness becomes so great that flow begins at the top this relation no longer holds. Furthermore, the diagrams for the thickest plate of each series, indicate that it was about as thick as could be rolled under that particular diameter of roller without producing initial longitudinal flow at the top of the plate. The upper diagrams of Fig. 22 to 26 inclusive cannot therefore be extended to the right beyond the range of the tests.

Each of the upper diagrams, Fig. 22 to 25 inclusive, has been represented by a straight-line equation and the equations for the various diagrams are given in the figures. These diagrams are all reproduced in Fig. 27.

The critical load as determined from the lateral flow is represented by the lower diagrams of Fig. 22 to 26 inclusive. These diagrams show that as the thickness of the plate is increased, the critical load increased, reached a maximum, and then decreased. The decrease in load for thick plates is quite definite for 116-inch and 476-inch cylinders but is not definite for 188-inch and 356-inch cylinders. The lack of correlation among the results of the tests is not surprising considering the character of flow.

The following considerations may have some bearing upon the relation between the thickness of a plate and its resistance to lateral flow. Lateral flow is greatest at the upper surface and decreases rapidly with the distance from the top. A thin plate has a tendency to flow throughout its entire depth, whereas a thick one has no flow except at the surface where the over-stressed material is supported against lateral flow by the low-stressed material beneath. The thin plate therefore flows laterally at a smaller load than a thick one. But as the thickness of the plate becomes greater and greater this influence becomes smaller and finally has no appreciable value. At the same time another influence is at work. The upper outside corner of


P = 8000 + 15000 t
Fig 22a
Critical Load
From Longitudinal Flow
Fig 22b
Critical Load
From Lateral Flow
Fig 22
Relation between
Thickness of Plate and Critical Load
Annealed Steel Casting
Diameter of Roller 116"
Thickness of Plate in Inches
Critical Load in Thousands of Pounds per Inch Width of Plate


P = 20000 + 97D
Fig 21
Relation Between
Diameter of Roller and
Critical Load as Determined
From Lateral Flow
Annealed Steel Castings
Plates 1.5 inches thick
Diameter of Roller in inches
Critical Load in 1000lb. per inch Width of Plate

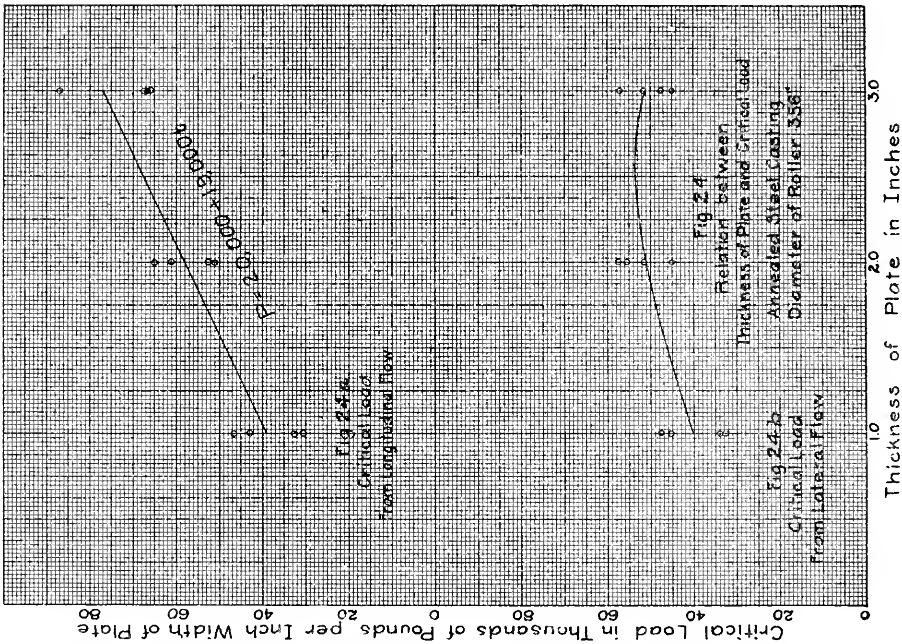


Fig 24 a
Critical Load
From Longitudinal Flow
P = 20,000 + 12,000t
Fig 24 b
Critical Load
From Lateral Flow
Fig 24
Relation between
Thickness of Plate and Critical Load
Annealed Steel Casting
Diameter of Roller 3.56"
Critical Load in Thousands of Pounds per Inch Width of Plate
Thickness of Plate in Inches

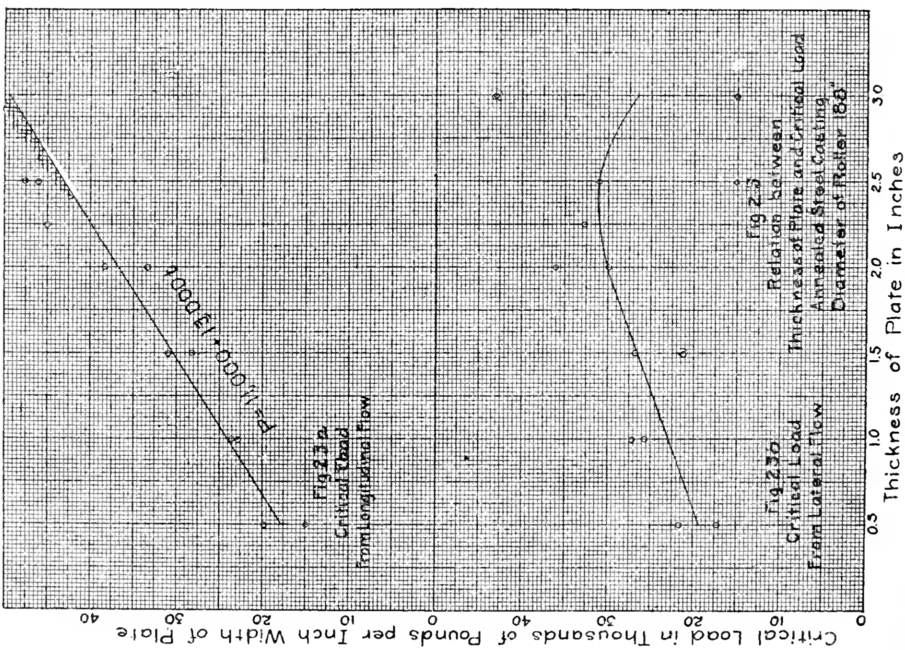


Fig 23 a
Critical Load
From Longitudinal Flow
P = 11,000 + 13,000t
Fig 23 b
Critical Load
From Lateral Flow
Fig 23
Relation between
Thickness of Plate and Critical Load
Annealed Steel Casting
Diameter of Roller 1.80"
Critical Load in Thousands of Pounds per Inch Width of Plate
Thickness of Plate in Inches

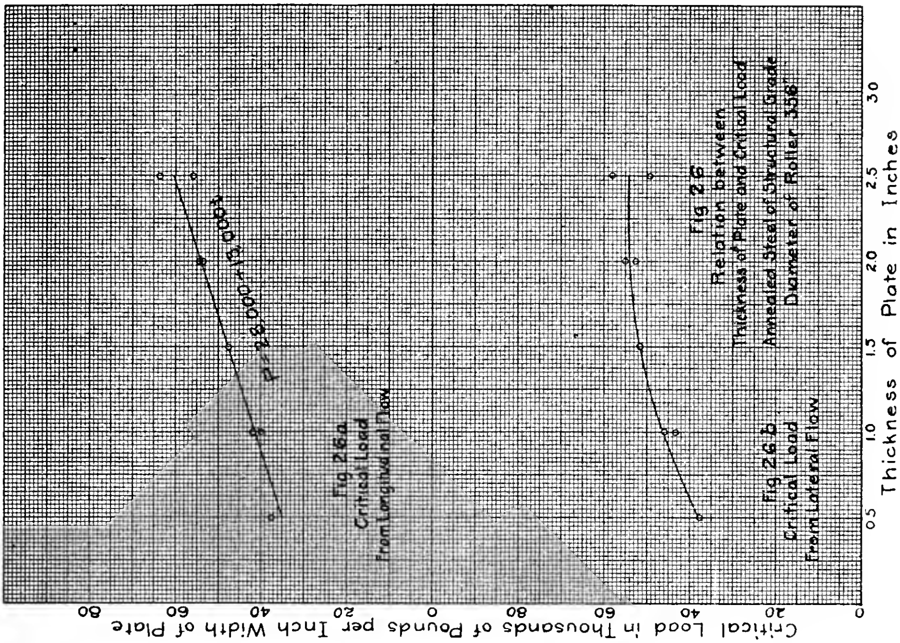


Fig. 26a
Critical Load
From Longitudinal Flow
P=28,000+13,000t
Fig. 26b
Critical Load
From Lateral Flow
Fig. 26
Relation between
Thickness of Plate and Critical Load
Annealed Steel of Structural Grade
Diameter of Roller 3.56"
Thickness of Plate in Inches
Critical Load in Thousands of Pounds per Inch Width of Plate

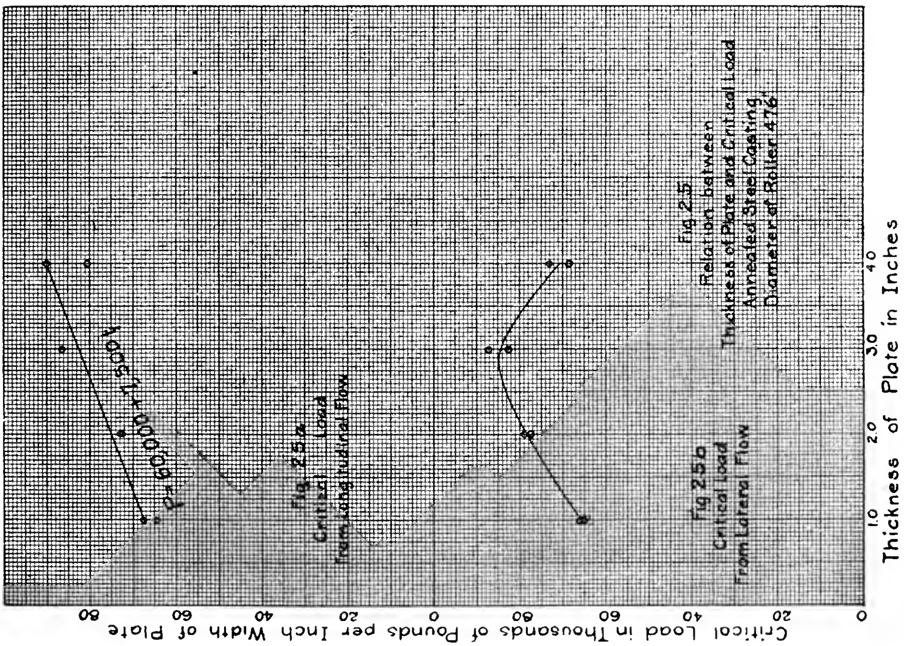


Fig. 25a
Critical Load
From Longitudinal Flow
P=60,000+1,300t
Fig. 25b
Critical Load
From Lateral Flow
Fig. 25
Relation between
Thickness of Plate and Critical Load
Annealed Steel Casting
Diameter of Roller 4.76"
Thickness of Plate in Inches
Critical Load in Thousands of Pounds per Inch Width of Plate

A

a transverse section is supported entirely by the shearing resistance on an inclined surface and its ability to resist a vertical load on its top surface is much less than that of a similar area further from the edge. The portion of the surface having an inferior carrying capacity increases with the thickness of the plate but the rate of increase become less and less. The total effect of varying the thickness of the plate is the resultant of the two influences, (1) the support against lateral flow offered by low-stressed material to the high-stressed material just above, and (2) the relation that the thickness of a plate bears to the width of the strip along the edge having a low load-bearing capacity. The resultant of these two influences could easily be consistent with the observed results.

10. **A Comparison of Carbon Steel Castings, Hylastic, and Steel of Structural Grade.**—Although most of the tests were made upon carbon steel castings of medium grade, a few tests were made upon an alloy steel sold under the trade name, Hylastic, and upon steel of structural grade.

In addition to those described in Sections 8, 9 and 10, tests were made upon carbon steel castings of medium grade furnished by the American Steel Foundries. Each specimen came from a separate casting and the castings were large enough so that in finishing at least 0.25 inches of metal was removed from each surface. The specimens were commercially annealed at the foundry but were not annealed at the laboratory. The physical and chemical properties are given in Tables 1 and 8.

The Hylastic plates contributed by the American Steel Foundries were machined from castings large enough so that at least 0.25 inch of metal was removed from each surface. The castings were normalized at the foundry but received no heat treatment at the laboratory.

Series L and M were tests of steel of structural grade bought on the open market. All specimens for the L series were cut from one bar and all for the M series were cut from another. For both series the piece from which the specimens were cut was annealed at the laboratory before the bar was cut up so that all specimens of a series received the same heat treatment. The original bars were large enough so that in finishing at least 0.25 inch of metal was removed from each surface.

The load required to produce flow for the various materials is given in Table 7. The plates for all tests reported in this table were 1.5 inches thick and the rollers for the first four were 236 inches and for the last five were 356 inches in diameter. The results given in this table indicate that specimens belonging to the same general classification give radically different results, due partly to a difference in the composition and partly to a difference in heat treatment. Specimens F5 and F6 are of the same grade of steel as C41 and C42, yet the latter have a 50 per cent greater carrying capacity than the former. Specimens F5 and F6 were annealed twice, once at the foundry and once at the laboratory, whereas C41 and C42 were annealed at the foundry only. Moreover, C41 and C42 contained 0.35 silicon and 0.70 manganese, whereas F5 and F6 contained only 0.046 silicon and 0.50 manganese.

Specimens L7 and L8, steel of structural grade, had a much lower carrying capacity than either F5 and F6 or C41 and C42, castings of medium grade. But the structural steel of Series M had practically double the capacity of the structural steel of Series L, and a comparison of the results given in Table 6 with those in Table 4 indicates that the structural steel plates of Series M had practically the same bearing capacity as the annealed steel castings of Series D. The Hylastic when normalized had a carrying capacity much greater than that of any of the annealed steels tested.

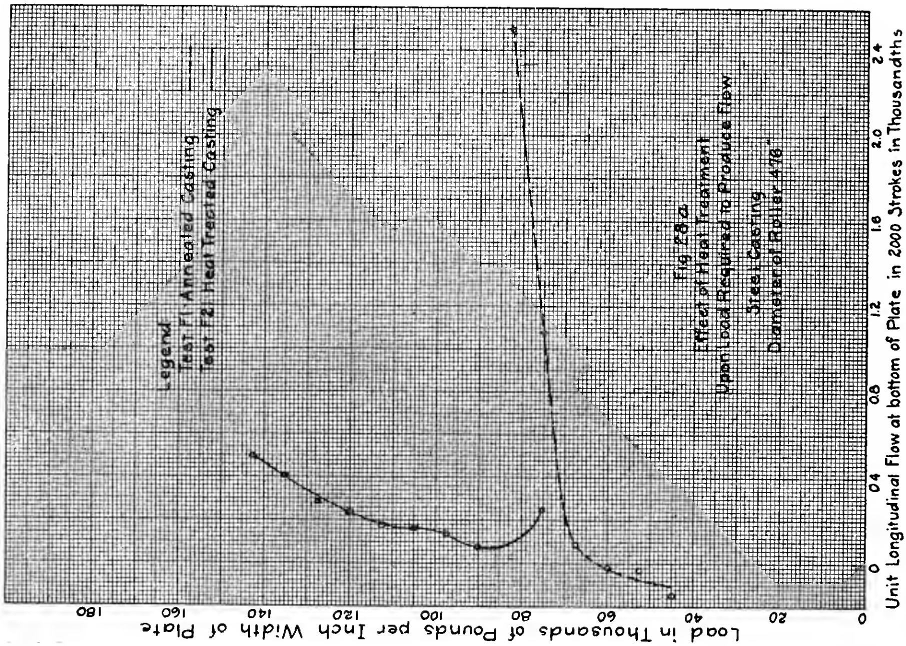
11. **Effect of Heat Treatment upon Load Required to Produce Permanent Deformation.**—A few tests were made upon plates that had been hardened by heat treatment. The steel castings used in these tests were cut from the same block as the other F specimens. The specimens were rough finished before being heat treated. All specimens of the same series were treated together. The heat treatment consisted of holding the blocks at a temperature of 1560 degrees Fahr. for 3 hours, quenching them in water, and drawing the temper by reheating to 800 degrees Fahr. and holding them at that temperature for approximately one hour. The structural steel specimens were some that had previously been annealed and tested; the specimen designated as L1 when annealed, became L1A when hardened; likewise L2 became L2A, etc. The structural steel specimens were held at a temperature of 1575 degrees Fahr. for one and one-fourth hours, quenched in water, and drawn at 800 degrees F.

The full-line diagrams of Fig. 28, 29 and 30 are the load-deformation curves for the hardened steel casting when tested under rollers having diameters of 476, 356 and 236 inches respectively. Some of these diagrams do not contain abrupt breaks and the load at which the deformation first increased rapidly with further increase of load is not clearly determined. In order that the effect of the heat treatment might be clearly apparent, the load-deformation curves for annealed steel castings are shown on the same figures, the latter diagrams being broken lines.

The full-line diagrams of Fig. 31, 32 and 33 are the load-deformation diagrams for the hardened steel of structural grade when tested under rollers 356, 236, and 116 inches in diameter, respectively. The broken lines of the same figures show the load-deformation relation for the same plates when annealed.

A comparison of the full-line and broken-line diagrams of Fig. 28 to 33 inclusive, indicates that the bearing capacity of even low carbon steel can be greatly increased by heat treatment.

12. **Effect of Strength of Material Upon Bearing Capacity of Plates.**—The specimens used in the tests described in Section 11 were made from materials having a wide variation in physical properties; a study has been made to determine the relation between the yield-point strength of the material in tension and the bearing capacity of the plates. The tests used in this study included only those for which the diameter of roller was 236 inches and the thickness of plate was 1.5 inches.


Legend
Test F1 Annealed Casting
Test F2 Heat Treated Casting
Fig. 28a
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel Casting
Diameter of Roller 4.76"
Unit Longitudinal Flow at bottom of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate

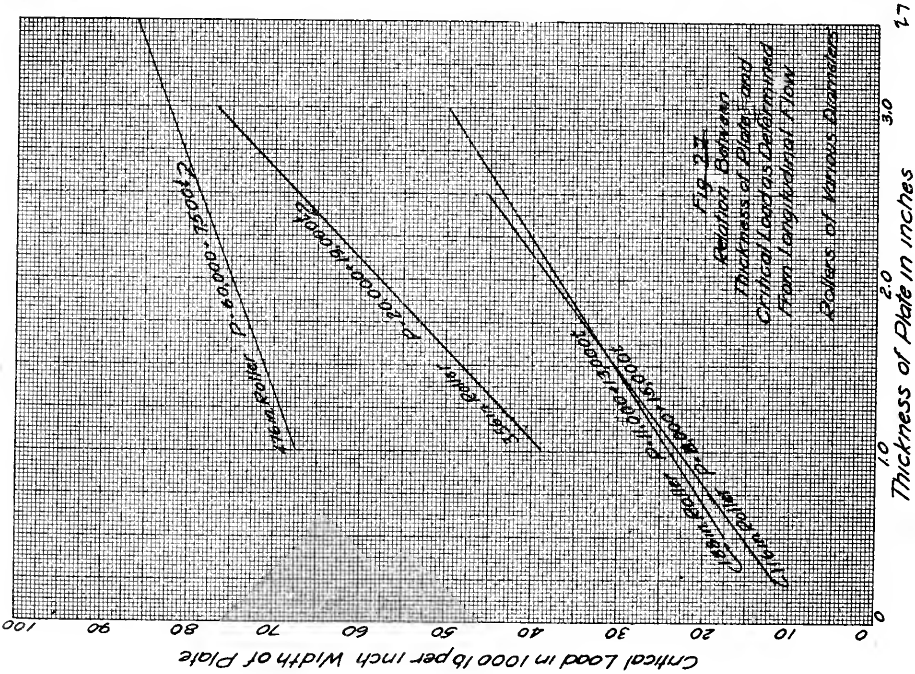
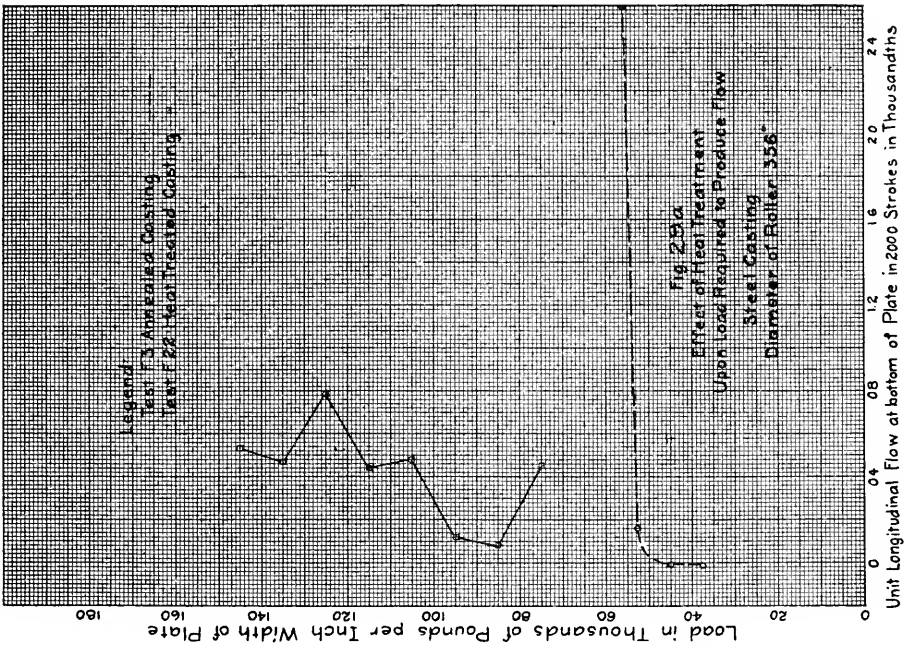
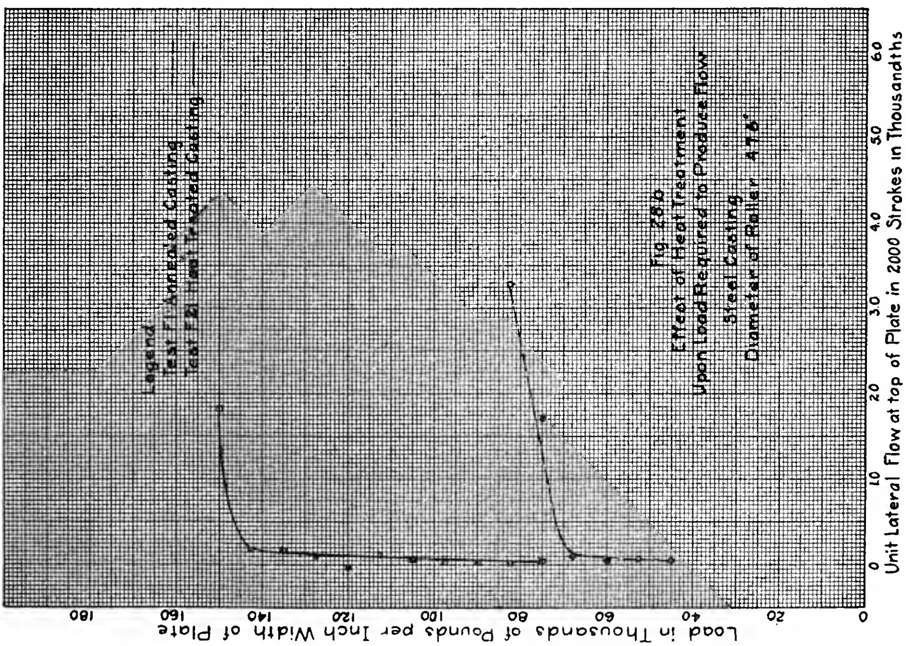
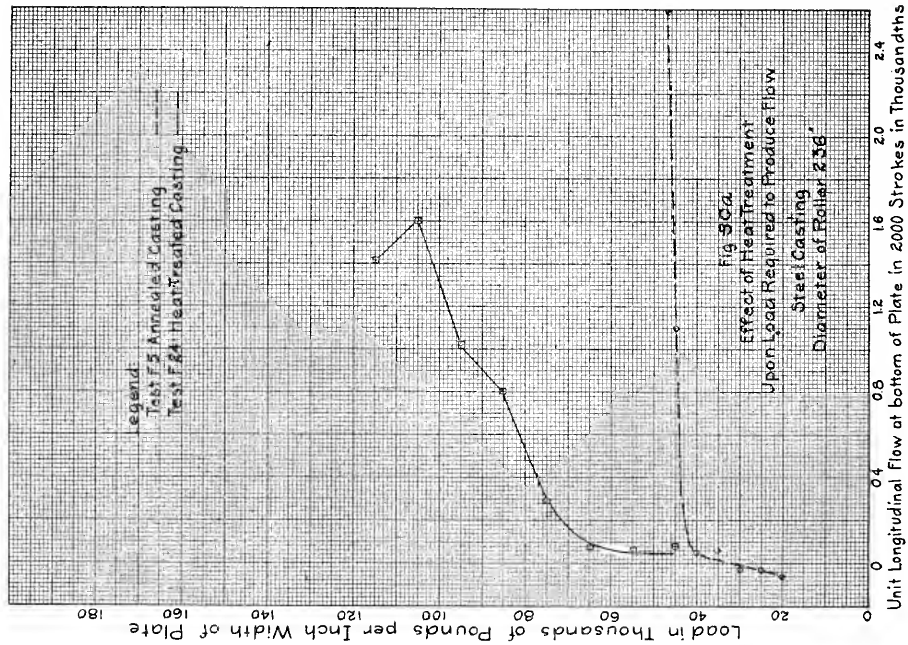
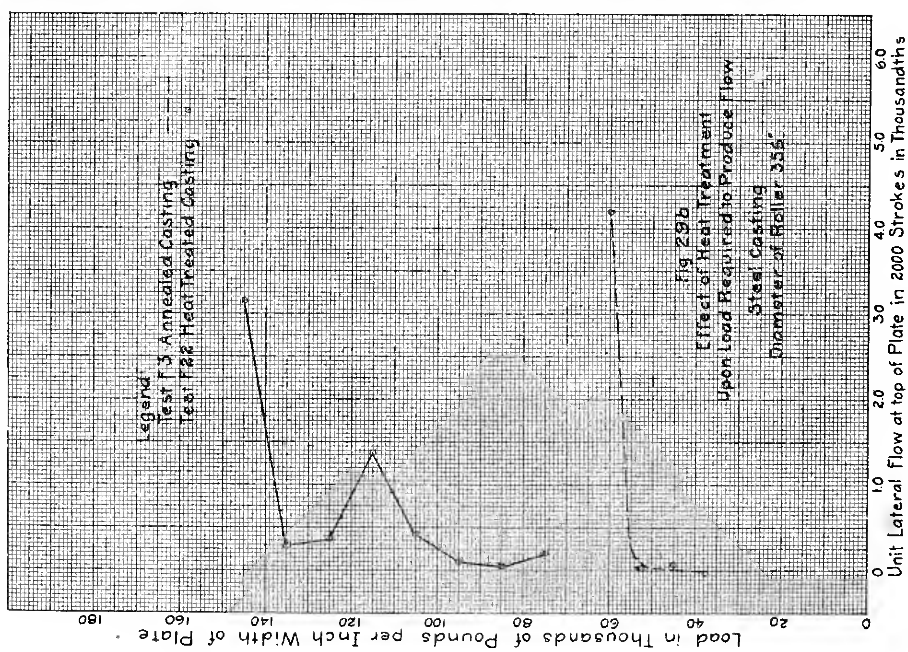


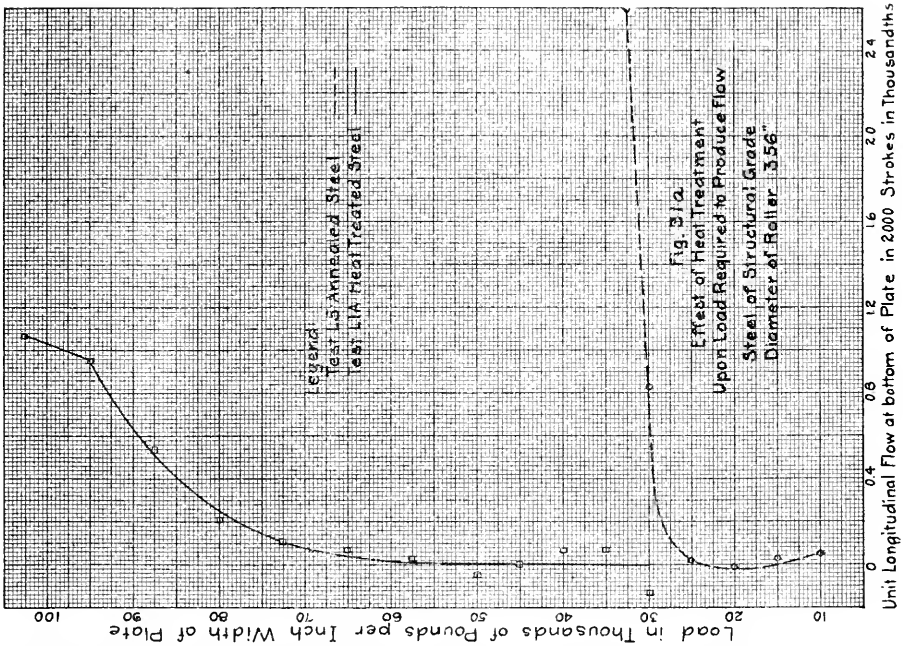
Fig. 27
Relation Between
Thickness of Plate T and
Critical Load as Determined
From Longitudinal Flow
Rollers of Various Diameters
Thickness of Plate in inches
Critical Load in 1000 lb per inch Width of Plate

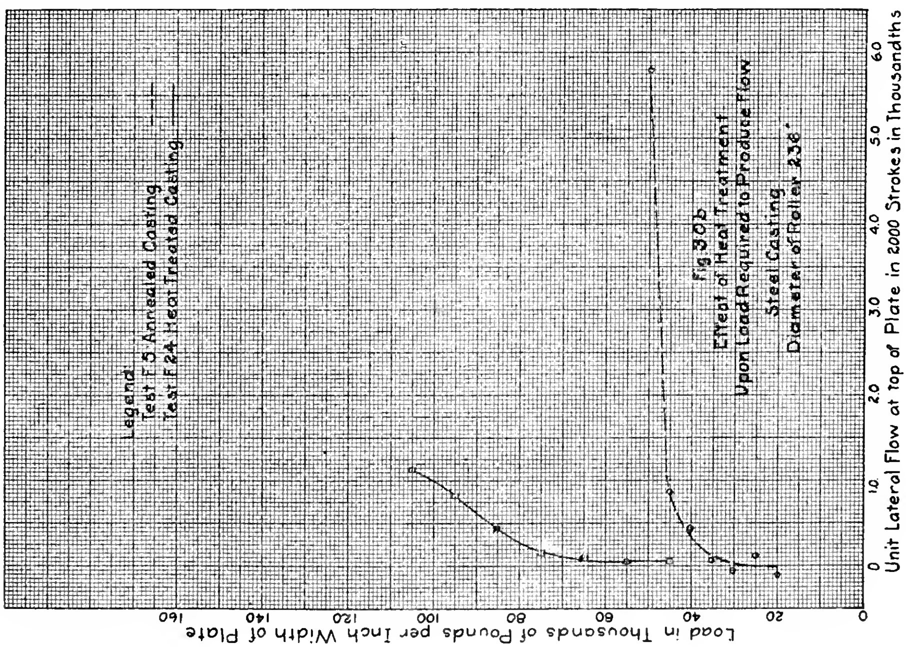

Legend
Test F3 Annealed Casting
Test F22 Heat Treated Casting
Fig. 28a
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel Casting
Diameter of Roller 3.56"
Unit Longitudinal Flow at bottom of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate
0
.04
.08
.12
.16
.20
.24
20
40
60
80
100
120
140
160
180


Legend
Test F1 Annealed Casting
Test F21 Heat Treated Casting
Fig. 28b
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel Casting
Diameter of Roller 4.76"
Unit Lateral Flow at top of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate
0
1.0
2.0
3.0
4.0
5.0
6.0
20
40
60
80
100
120
140
160
180


Legend:
Test F.5 Annealed Casting
Test F.24 Heat Treated Casting
Fig 30a
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel Casting
Diameter of Roller 2.56"
Unit Longitudinal Flow at bottom of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate


Legend:
Test F.3 Annealed Casting
Test F.22 Heat Treated Casting
Fig 29b
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel Casting
Diameter of Roller 3.56"
Unit Lateral Flow at top of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate


Legend:
Test L3 Annealed Steel
Test L1A Heat Treated Steel
Fig. 31a
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel of Structural Grade
Diameter of Roller 3.56"
Unit Longitudinal Flow at bottom of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate


Legend:
Test F5 Annealed Casting
Test F24 Heat Treated Casting
Fig. 30b
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel Casting
Diameter of Roller 2.36"
Unit Lateral Flow at top of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate

The relations between the yield-point strength of the material and the critical load as determined from lateral flow and from longitudinal flow are given in Fig. 34 and 35 respectively.

The elastic behavior of a cylinder bearing upon a plane surface was analyzed by Hertz. His expression for the area in contact, in the case of steel bodies, reduces to the form,[1] $a = 0.00040 \sqrt{P D}$, in which a is the width of the area in contact in inches, D is the diameter of the cylinder in inches, and P is the load in pounds per inch width of plate. Hertz also assumed the maximum intensity of the pressure to be 1.27 times the average over the area in contact. The latter relation gives $a = \frac{1.27 P}{p}$, in which p is the maximum intensity of pressure in pounds per square inch. Equating the two values for a, gives $\frac{1.27 P}{p} = 0.00040 \sqrt{PD}$. Solving this equation for P, gives $P = 0.000{,}00010 p^2 D$ as the relation between the total load per inch width of the plate and the maximum intensity of pressure between the cylinder and plate, expressed in pounds per square inch. This equation is based upon the assumption that strain is proportional to stress and therefore is not applicable beyond the elastic limit of the material, although it is approximately correct up to the yield-point.

The yield-point load as determined from Hertz's formula and the experimentally determined critical load are compared in Fig. 34 and 35, the critical load for the two diagrams being determined from the lateral and the longitudinal flow, respectively. The full-line diagrams represent values computed by Hertz's[2] formula and the small circles represent experimentally determined values.

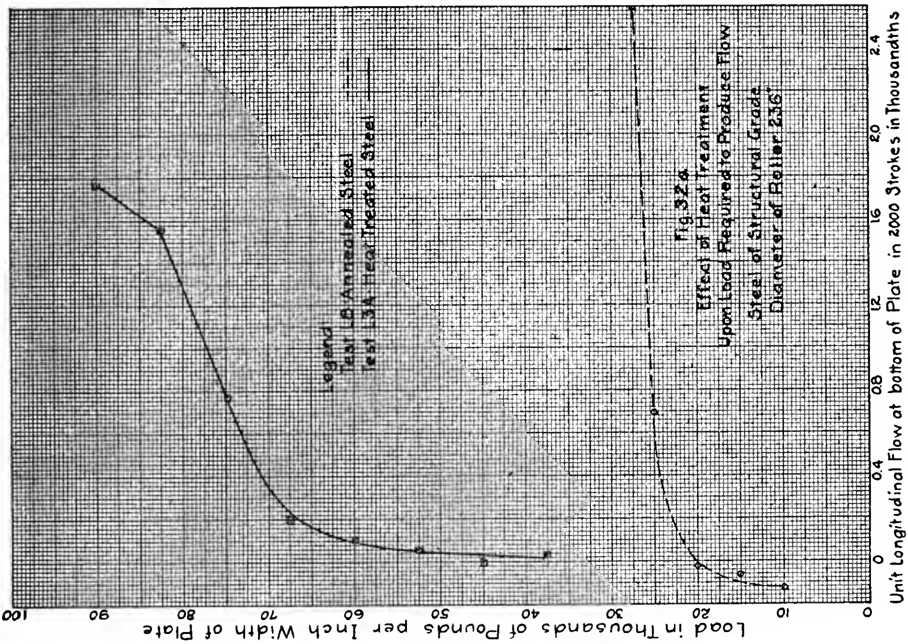
The experimental values are somewhat greater than the theoretical ones. Two influences contribute to this discrepancy: (1) A region of high localized stress seems to be supported if it is surrounded, or nearly so, by a region of low stress. This condition exists in the case of a cylinder lying on a plane surface and the elastic limit of the material under the conditions at the point of maximum intensity of pressure is probably greater than the elastic limit of the same material when subjected to a standard tension test. (2) The yield-point is a little greater than the elastic limit for all materials and the deformation is considerably greater at the yield-point than at the elastic limit. This deformation increases the area in contact, so that the total yield-point load exceeds the elastic-limit load more for a cylinder lying on a plane than for a standard tension test.

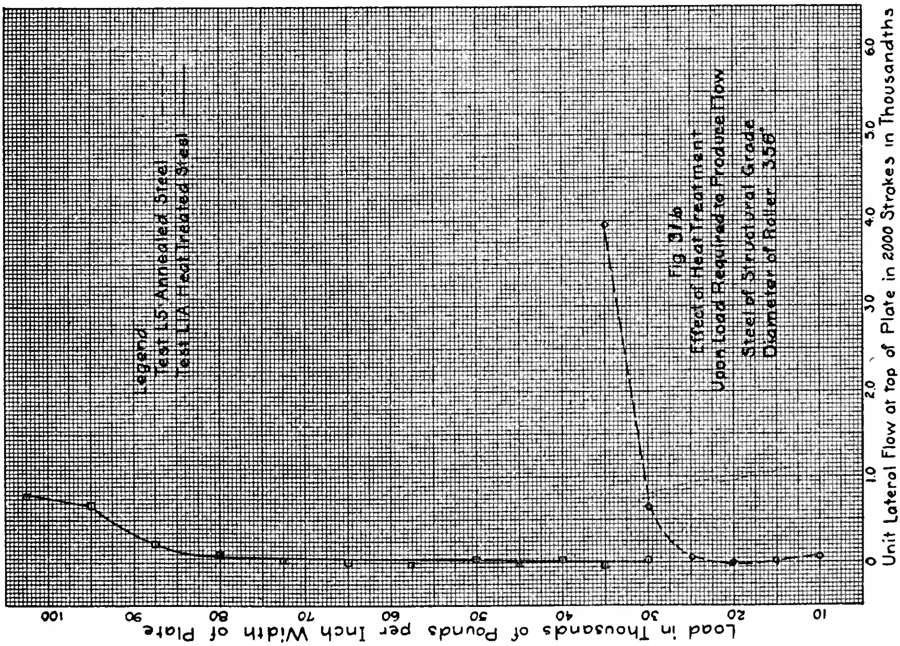
The combined effect of the two influences just described would seem to explain the discrepancy between the theoretical and measured critical loads.

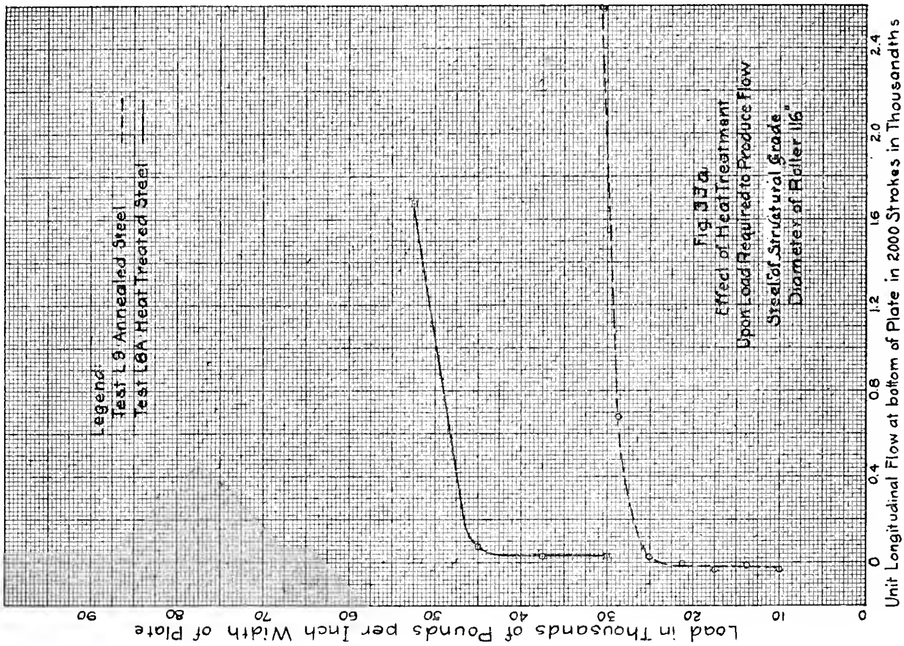
The ordinates of the dotted-line diagrams of Fig. 34 and 35 exceed the ordinates of the Hertz diagram by 40 per cent. Since the dotted lines well represent the results of the tests, the critical load determined by rolling

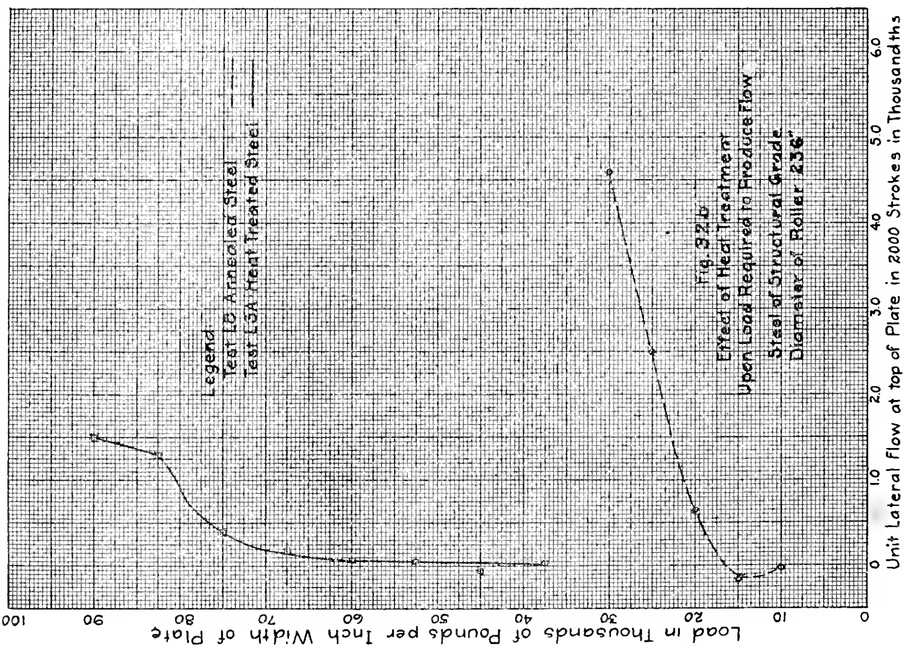
[1]Bulletin 162, Engineering Experiment Station, University of Illinois, page 56.

[2] Hertz's formula is based upon the assumption that the plate is of infinite width and infinite depth and is not directly applicable.


Legend
Test L6 Annealed Steel
Test L3A Heat Treated Steel
Fig. 32 a
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel of Structural Grade
Diameter of Roller 2.36"
Unit Longitudinal Flow at bottom of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate


Legend
Test L5 Annealed Steel
Test L1A Heat Treated Steel
Fig. 31 b
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel of Structural Grade
Diameter of Roller 3.56"
Unit Lateral Flow at top of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate


Legend:
Test L9 Annealed Steel
Test L9A Heat Treated Steel
Fig. 32 a
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel of Structural Grade
Diameter of Roller 1.6"
Unit Longitudinal Flow at bottom of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate


Legend:
Test L6 Annealed Steel
Test L6A Heat Treated Steel
Fig. 32 b
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel of Structural Grade
Diameter of Roller 2.36"
Unit Lateral Flow at top of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate

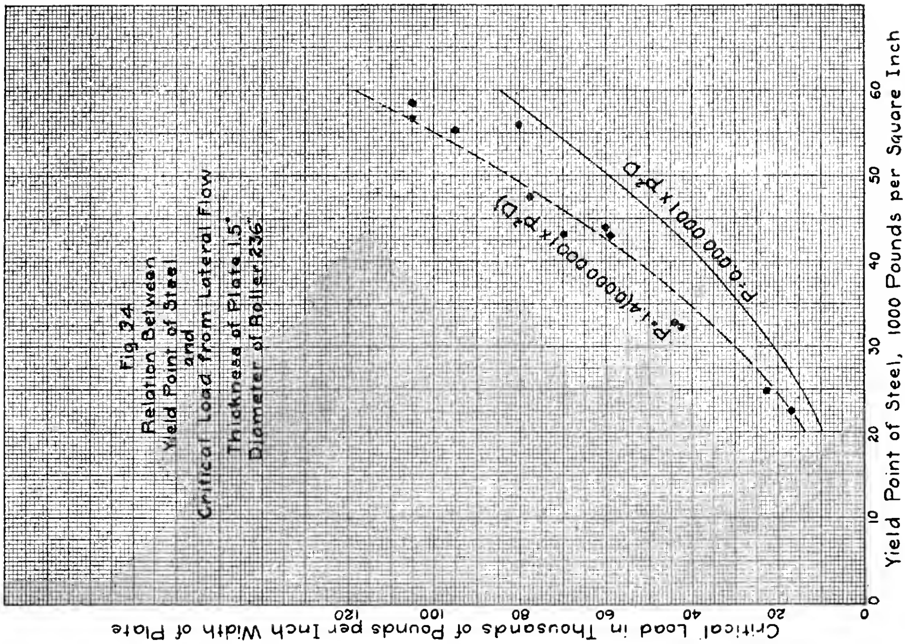
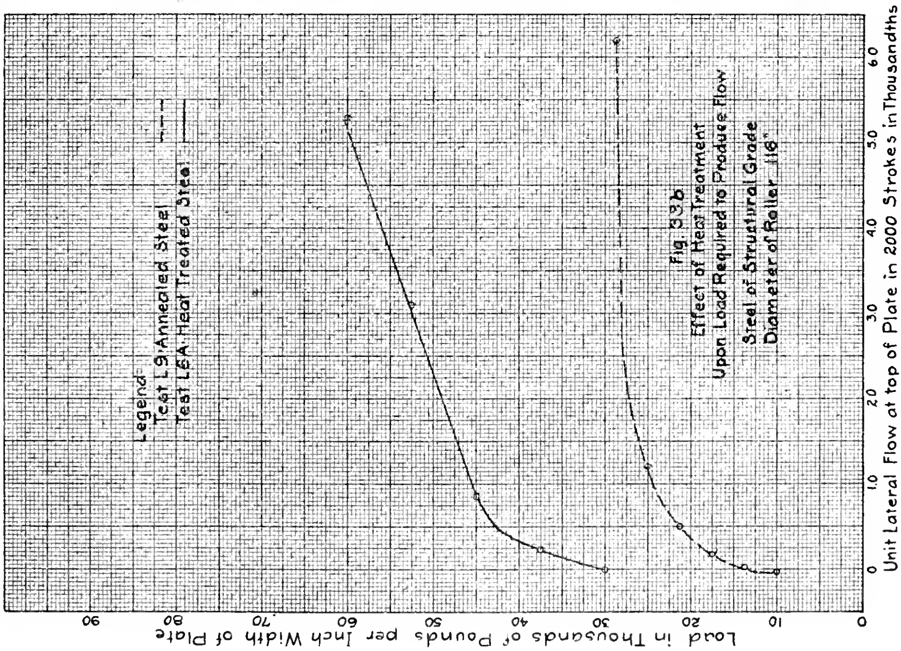


Fig. 34
Relation Between
Yield Point of Steel
and
Critical Load from Lateral Flow
Thickness of Plate 1.5"
Diameter of Roller 2.36"
P=0.0000001 x P_t D
P=1.4(0.0000001 x P_t D)
Yield Point of Steel, 1000 Pounds per Square Inch
Critical Load in Thousands of Pounds per Inch Width of Plate


Legend:
Test L9 Annealed Steel
Test L6A Heat Treated Steel
Fig. 33b
Effect of Heat Treatment
Upon Load Required to Produce Flow
Steel of Structural Grade
Diameter of Roller 1.16"
Unit Lateral Flow at top of Plate in 2000 Strokes in Thousandths
Load in Thousands of Pounds per Inch Width of Plate

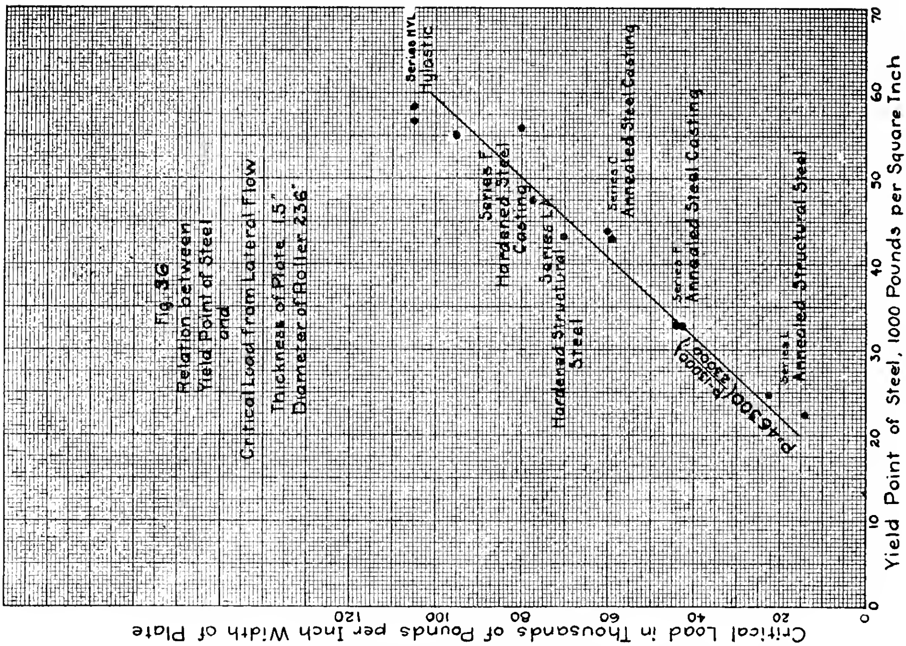


Fig. 36
Relation between
Yield Point of Steel
and
Critical Load from Lateral Flow
Thickness of Plate 1.5"
Diameter of Roller 2.36"
Series HYL
Hylastic
Series F
Hardened Steel
Casting
Series L
Hardened Structural
Steel
Series C
Annealed Steel Casting
Annealed Steel Casting
Annealed Structural Steel
Yield Point of Steel, 1000 Pounds per Square Inch
Critical Load in Thousands of Pounds per Inch Width of Plate

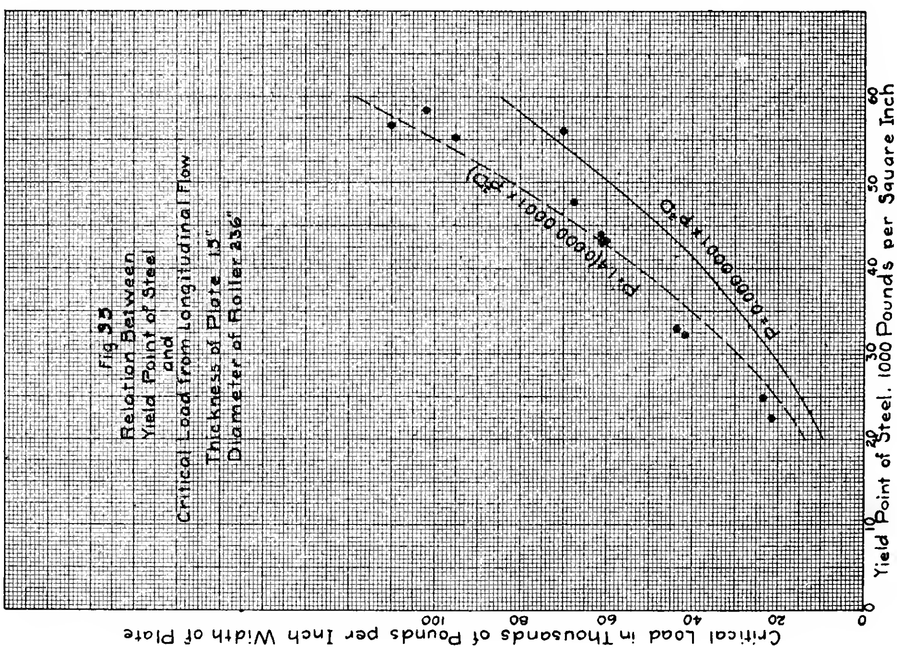


Fig. 35
Relation Between
Yield Point of Steel
and
Critical Load from Longitudinal Flow
Thickness of Plate 1.5"
Diameter of Roller 2.36"
Yield Point of Steel. 1000 Pounds per Square Inch
Critical Load in Thousands of Pounds per Inch Width of Plate

tests would seem to exceed the yield-point load as given by Hertz's formula by 40 per cent. It should be noted, however, that the experimental values are for one diameter of roller, 236 inches, and one thickness of plate, 1.5 inches. Hertz's formula takes into account the diameter of roller but does not take into account the thickness of plate. If the plates had been either thicker or thinner the experimental values would have been different but the computed values would have remained the same.

The relation between the critical load and the yield-point of the material is well represented by a second degree curve but it can be represented almost as well by a straight line. Thre are so many variabls involved and their influences so uncertain, that a design formula of the second degree does not seem warranted. The bearing capacity of 1.5-inch plates rolled under 236-inch cylinders is well represented by the empirical straight-line equation $P = 46{,}300 \left[\frac{p - 13{,}000}{23{,}000}\right]$, in which P is the critical load in pounds per inch width of plate and p is the yield-point strength of the material in tension in pounds per square inch. The full-line diagrams of Fig. 36 and 37 represent this formula and the small circles represent the critical loads determined by the tests.

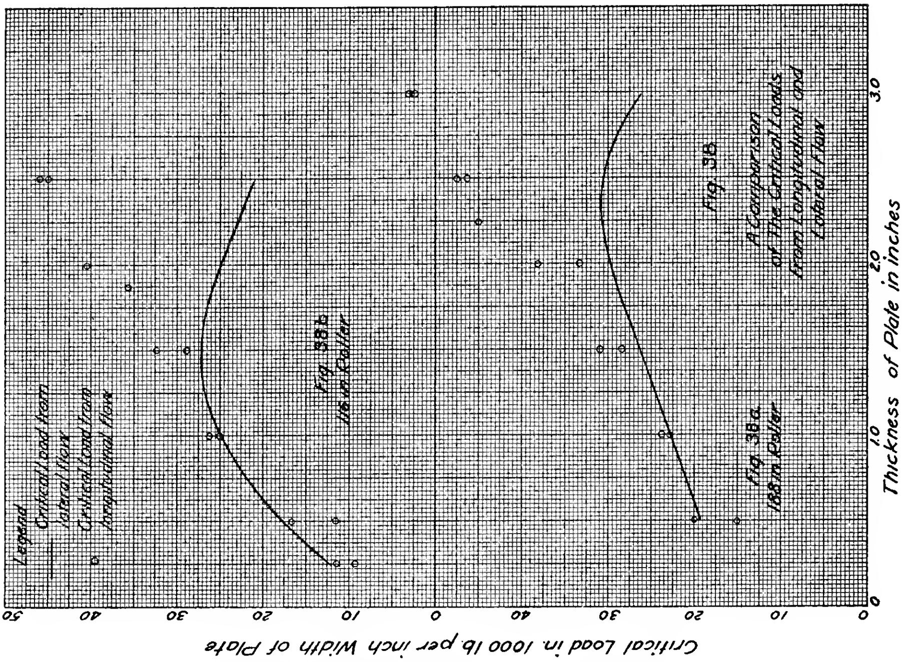
13. **Design Formula for Plates Rolled under Loaded Cylinders.** The tests were planned to determine the minimum load that would produce flow in a plate rolled under a loaded cylinder, the assumption being that the design load for such plates should be based upon the minimum load that would produce flow. The tests that have been described indicate that the bearing capacity of a plate depends upon its thickness, the strength of the material, and the diameter of the roller. A design formula should therefore take into account all of these variables.

The tests described in Section 9 indicate that the load required to produce longitudinal flow increased with the thickness of the plate; and that as the thickness of the plate increased the load required to produce lateral flow first increased, then remained constant, and eventually decreased. These relations are shown in Figures 22 to 25 inclusive. The relation between the load required to produce lateral and longitudinal flow is given in Fig. 38a, 38b, 38c, and 38d. The full-line diagrams, reproduced from Fig. 22 to 26 inclusive, show the load required to produce lateral flow and the small circles indicate the load required to produce longitudinal flow. Inasmuch as a properly designed plate should have neither lateral nor longitudinal flow, longitudinal flow will govern for thin plates and lateral flow for thick ones. Moreover, when the plate is so thick that lateral flow governs, increasing the thickness does not increase the strength. The experimental data is somewhat inconsistent but the following statements are fairly well supported by the tests and by general considerations of design.

1. Lateral flow governs if the thickness of the plate exceeds $.008D$.

2. Increasing the thickness of the plate beyond $.008D$ does not increase the resistance to lateral flow.

3. The thickness of a plate rolled under a larger loaded cylinder should not be less than $.008D$.


Legend
Critical Load from Lateral Flow
Critical Load from Longitudinal Flow
Fig. 38b 1.16 in. Roller
Fig. 38a 1.88 in. Roller
Fig. 38
A Comparison of The Critical Loads From Longitudinal and Lateral Flow
Thickness of Plate in inches
Critical Load in 1000 lb. per inch Width of Plate

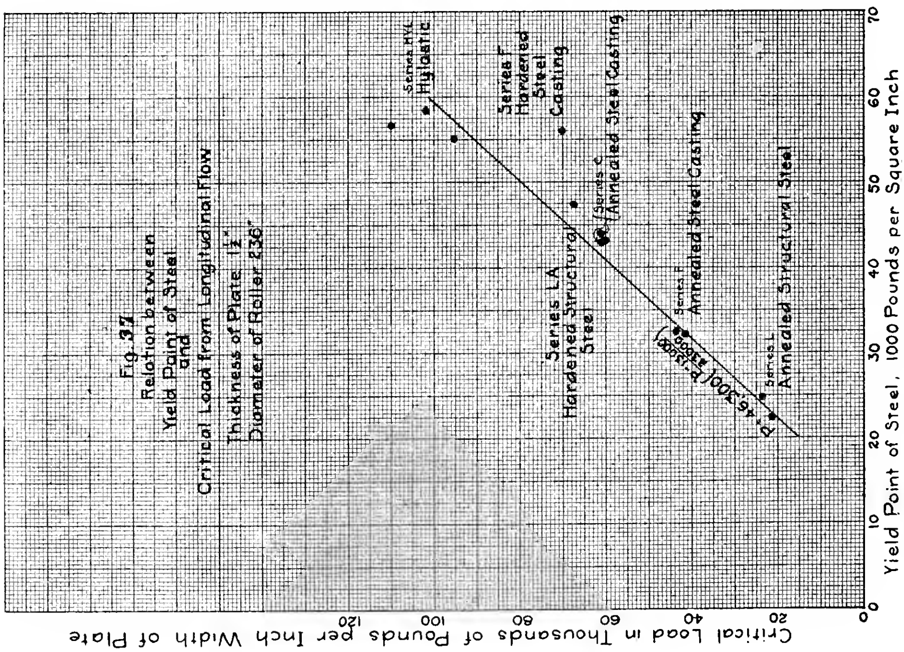


Fig. 37
Relation between Yield Point of Steel and Critical Load from Longitudinal Flow
Thickness of Plate 1½"
Diameter of Roller 2.36"
Series HYL Hylastic
Series F Hardened Steel Casting
Series C Annealed Steel Casting
Series LA Hardened Structural Steel
Series F Annealed Steel Casting
Series L Annealed Structural Steel
Yield Point of Steel, 1000 Pounds per Square Inch
Critical Load in Thousands of Pounds per Inch Width of Plate

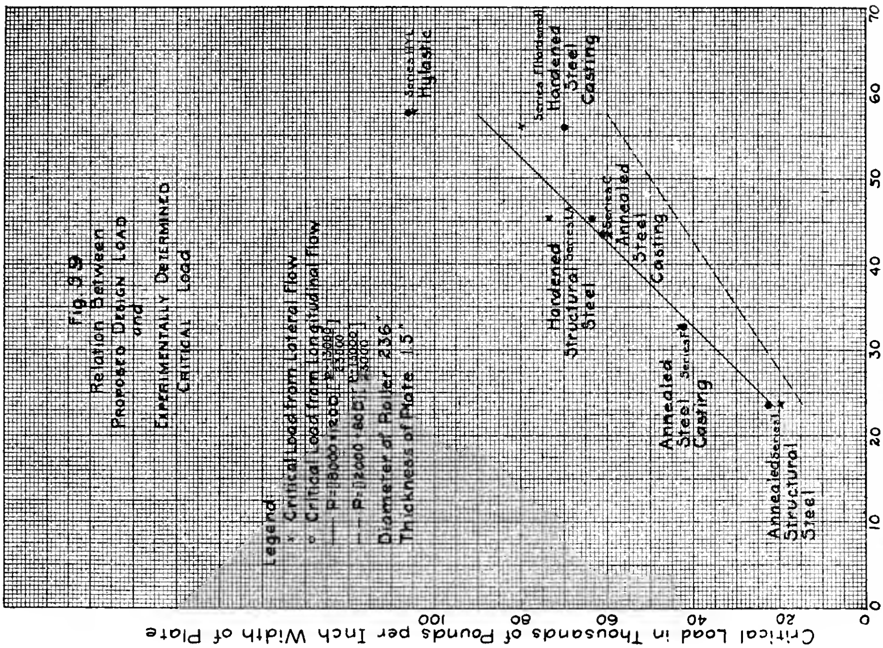
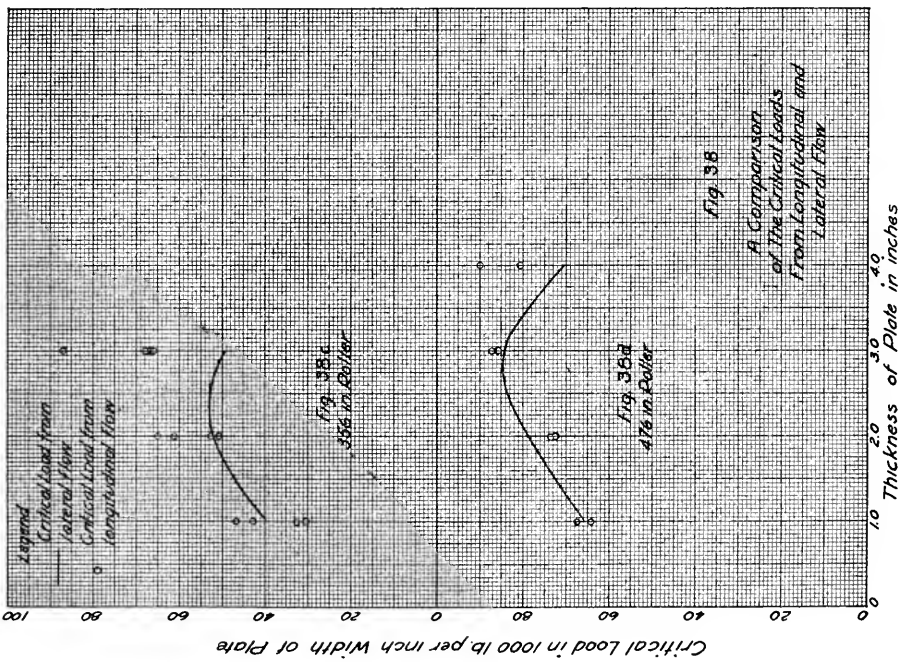


Fig 39
Relation Between
Proposed Design Load
and
Experimentally Determined
Critical Load
Legend
× Critical Load from Lateral Flow
○ Critical Load from Longitudinal Flow
Diameter of Roller 2.36"
Thickness of Plate 1.5"
Annealed Structural Steel
Annealed Steel Casting
Hardened Structural Steel
Annealed Steel Casting
Hardened Steel Casting
Hylastic
Yield Point of Steel, 1000 Pounds per Square Inch
Critical Load in Thousands of Pounds per Inch Width of Plate


Legend
Critical Load from lateral flow
Critical Load from longitudinal flow
Fig. 38c
3.56 in. Roller
Fig. 38d
4.76 in. Roller
Fig. 38
A Comparison of The Critical Loads From Longitudinal and Lateral Flow
Thickness of Plate in inches
Critical Load in 1000 lb. per inch Width of Plate

If these statements are accepted, the influence of the thickness of the plate upon the design load can be adequately provided for by requiring that the thickness of the plate be not less than .008*D*, in which *D* is the diameter of the roller.[3]

The tests described in Section 8 indicate that the relation between the critical load and the diameter of the roller is given by a straight-line equation of the form $P = K + CD$.

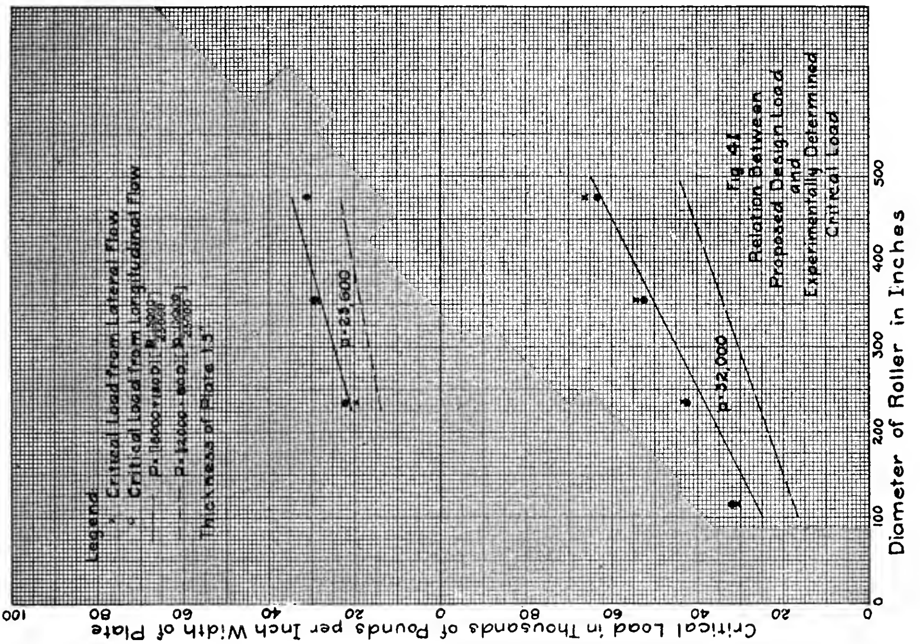
The tests described in Section 12 indicate that the relation between the critical load and the yield-point strength of the material is given by an equation of the form $P = K\left[\frac{p - 13{,}000}{23{,}000}\right]$, in which p is the yield-point strength of the material and K is a constant depending upon the diameter of roller. Combining the effects of the two variables, diameter of roller and strength of the material, gives $P = [K + CD]\left[\frac{p - 13{,}000}{23{,}000}\right]$. After many trials K and C were assigned the values of 18,000 and 120, respectively. The equation then became $P = [18{,}000 + 120\,D]\left[\frac{p - 13{,}000}{23{,}000}\right]$, in which P is the critical load in pounds per inch width of plate, D is the diameter of the roller in inches, and p is the yield-point strength of the material in tension in pounds per square inch. This equation is applicable to plates whose thickness equals or exceeds .008*D*.

The merits of the proposed empirical equation for the critical load depends upon the accuracy with which it represents the experimental data. Table 9 contains the results of a large number of tests for which t, D, and p vary through a wide range. The critical load determined by the empirical equation is given in column 5, and the value of the same quantity as determined by the lateral and longitudinal flow, is given in columns 7 and 8 of the same table.

The computed and experimentally determined values for series F, F hardened, *L*, and *LA* are compared graphically in Fig. 39, 40 and 41. In these figures, the full-line represents the empirical equation, the small circles represent the load required to produce longitudinal flow and the small crosses represent the load required to produce lateral flow. Fig. 39 shows the relation between critical load and the yield-point strength of the steel, the diameter of roller being 236 inches for all tests; Fig. 40 and 41 show the relation between the critical load and diameter of roller, the strength of the material having the same value for all tests of each series. For the tests represented in Fig. 39, 40, 41, the agreement between the empirical and experimental values is excellent, considering the character of the variables and the extent of the variations.

Series E, A, M, D, B, C, and C-HYL are not sufficiently extensive for the empirical and experimental values to be compared graphically. A comparison of the tabulated values, however, shows that the empirical and experimental values agree well for series M, D, B, C, and C HYL but

[3] Whether the limit is .006D, .008D, or .007D is largely a matter of judgment.


Legend
Critical Load from Lateral Flow
Critical Load from Longitudinal Flow
Thickness of Plate 1.5"
p=23,600
p=32,000
Fig. 41
Relation Between
Proposed Design Load
and
Experimentally Determined
Critical Load
Diameter of Roller in Inches
Critical Load in Thousands of Pounds per Inch Width of Plate

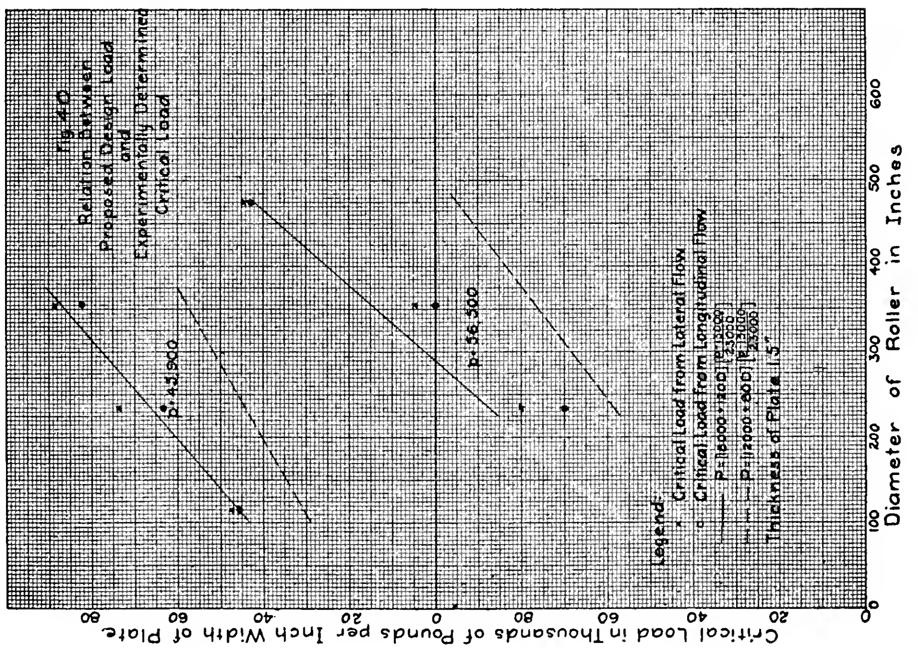


Fig. 40
Relation Between
Proposed Design Load
and
Experimentally Determined
Critical Load
p=43,900
p=36,500
Legend:
Critical Load from Lateral Flow
Critical Load from Longitudinal Flow
Thickness of Plate 1.5"
Diameter of Roller in Inches
Critical Load in Thousands of Pounds per Inch Width of Plate.

that the empirical values are a litle too high for series A and E. The roller for series E was 116 inches in diameter and the first impression is that the formula gives values that are too high for small rollers. This impression is not supported, however, by the tests of the 116-inch rollers in series F, L, and LA.

Considering all of the data, the discrepancy between the empirical and experimental values is no greater than the discrepancies between various sets of experimental values.

The design load should be based upon the critical load but the relation between the two is a matter of judgment. The failure of a sole plate will take place gradually and impending failure can be detected. For this reason the factor of safety for a plate rolled under a cylinder need not be as great as for a tension, compression, or flexural member. The yield-point of steel of structural grade is usually about 32,000 pounds per square inch, making a ratio of design stress to yield-point of one-half. A ratio of design load to critical load of two-thirds for sole plates, would therefore seem reasonable and that ratio is recommended. On this basis the design load for plates rolled under loaded cylinders will be given by the equation $P = \frac{2}{3}[18{,}000 + 120\,D]\left[\frac{p - 13{,}000}{23{,}000}\right]$, or $P = [12{,}000 + 80\,D]\left[\frac{p - 13{,}000}{23{,}000}\right]$ in which P is the design load in pounds per inch width of plate, D is the diameter of the roller in inches, and p is the yield-point strength of the material in tension in pounds per square inch. This equation is limited to the design of plates whose thickness is not less than $.008D$ and to cases for which the diameter of the roller is not less than 120 inches.

The working load and the experimentally determined critical load are compared graphically in Fig. 39, 40 and 41, the dotted-line diagrams representing the design load. The two quantities are also given in Table 9, the design load being given in column 6 and the critical loads in columns 7 and 8.

14. **Summary of Results.** The results of the tests described in this report may be summarized as follows.

1. When a loaded cylinder rolls over a plate the deformation of the plate is influenced by the motion as well as by the pressure.

2. The plastic flow under a rolling cylinder is materially different in character from the elastic deformation under the same cylinder at rest, the former being opposite in sense from the latter for some important deformations.

3. Within the scope of these tests, the load required to produce longitudinal flow increased with the thickness of plate. There were indications, however, that an increase in thickness of plate beyond 4 inches might not be accompanied by a further increase in the load required to produce longitudinal flow. Likewise, there were indications that a decrease in the thickness of plate below 0.25 inch might be accompanied by an increase in the load required to produce longitudinal flow.

4. The load required to produce lateral flow increased with the thickness of plate for thin plates but decreased as the thickness increased, for thick ones. The thickness of plate that had the greatest capacity to resist lateral flow was greater for large cylinders than for small ones, being roughly 1.5 inches for a 116-inch and 3.0 inches for a 476-inch cylinder.

5. The bearing capacity of a plate on which a cylinder rolls is greatly affected by slight changes in the physical properties of the material.

6. The bearing capacity of a steel casting of medium grade and of steel of structural grade can be greatly increased by proper heat treatment.

7. The tests seem to justify the following formula for the design of plates under loaded cylinders, $P = [12{,}000 + 80\,D] \left[\frac{p - 13{,}000}{23{,}000}\right]$ in which P is the safe working load in pounds per inch width of plate, D is the diameter of roller in inches, and p is the yield-point strength of the material in tension in pounds per square inch. For this equation to be applicable the thickness of the plate shall be not less than $.008D$ shall be not less than 120 inches. The design load given by the above formula is approximately two-thirds of the minimum load required to produce flow under continuous rolling.

8. The load bearing capacity of a plate rolled under a cylinder varies as the square of the yield-point strength of the material.

TABLE 1—CHEMICAL COMPOSITION OF MATERIALS

		Chemical Composition				
Specimens	*Kind of Material*	*C*	*P*	*S*	*Si*	*Mn*
A, B, D, E and F	Steel Casting	0.283	.....	0.043	0.046	0.496
C	Steel Casting	0.30	0.02	0.035	0.35	0.70
C, H, Y, L	Steel Casting	0.35	0.02	0.03	0.40	1.45
L	Hot Rolled Steel	0.158	0.010	0.022	0.023	0.420
M	Hot Rolled Steel	0.317	0.020	0.044	0.014	0.728

TABLE 2—CRITICAL LOADS FOR PLATES OF VARIOUS THICKNESSES

Series A

Diameter of Roller 188 Inches

Annealed Steel Castings of Medium Grade

Test No.	*Thickness of Plate*	*Critical Load from Lateral Flow*		*Critical Load from Longitudinal Flow*			
		a	*c*	*a*	*b*	*c*	*d*
A3	1.5	26,500	21,200	32,300	34,100	28,300	30,000
A4	2.0	32,600	30,000	37,500	39,500	33,400	32,900
A5	0.5	21,000	17,200	21,500	22,600	15,000	16,900
A6	1.0	28,600	27,300	27,300	28,200	23,500	25,400
A7	1.5	31,700	26,900	35,000	35,700	31,000	32,100
A8	1.0	28,100	25,700	26,800	28,000	23,000	24,900
A9	2.0	38,500	36,100	43,500	43,400	38,300	37,800
A10	2.5	26,700	15,000	54,200	54,200	47,500	47,500
A11	2.5	35,700	31,200	51,600	51,600	46,300	46,300
A12	3.0	45,000	43,000	69,800	70,500	52,500	62,700
A13	0.5	22,700	21,700	21,200	22,200	19,900	19,700
A14	3.0	31,500	15,000	58,500	62,400	53,000	53,000
A16	2.25	35,600	32,600	48,500	48,500	45,000	45,000

a. Load that produced flow of 0.001 inches per inch at point where flow first occurs.
b. Load that produced an average flow over the entire depth of 0.001 inches per inch.
c. Load corresponding to the break in the diagram showing the flow at the point where flow first occurred.
d. Load corresponding to the break in the diagram showing the average flow over the entire depth.

TABLE 3—CRITICAL LOADS FOR PLATES OF VARIOUS THICKNESSES

Series B

Diameter of Roller 476 Inches

Annealed Steel Castings of Medium Grade

Test No.	*Thickness of Plate*	*Critical Load from Lateral Flow*		*Critical Load from Longitudinal Flow*			
		a	*c*	*a*	*b*	*c*	*d*
B1	1.0	70,600	66,000	74,100	74,100	67,500	67,500
B2	2.0	81,300	79,200	78,100	80,600	73,000	77,500
B3	3.0	84,500	82,500	94,500	95,400	86,500	90,000
B4	1.0	68,100	65,000	67,500	68,700	64,100	63,500
B5	2.0	80,700	77,400	79,700	81,300	72,500	76,000
B6	3.0	88,200	87,400	91,800	93,000	86,700	91,000
B7	4.0	76,500	73,100	111,500	112,300	90,000	78,100
B8	4.0	72,200	68,200	96,000	106,000	80,300	98,000

See footnote bottom of Table 2.

TABLE 4—CRITICAL LOADS FOR PLATES OF VARIOUS THICKNESSES

Series D

Diameter of Roller 356 Inches

Annealed Steel Castings of Medium Grade

Test No.	Thickness of Plate	Critical Load from Lateral Flow *a*	Critical Load from Lateral Flow *c*	Critical Load from Longitudinal Flow *a*	*b*	*c*	*d*
D 1	1.0	50,700	47,500	48,500	49,200	43,000	45,300
D 2	2.0	62,000	57,500	70,000	70,000	65,000	65,000
D 3	3.0	61,500	57,000	94,400	96,500	87,000	89,000
D 5	2.0	54,200	51,300	55,000	56,500	52,500	51,900
D 6	3.0	55,000	51,300	76,200	78,100	67,000	71,800
D 7	1.0	41,000	32,500	39,000	42,500	32,500	32,500
D 8	2.0	49,700	45,000	58,000	58,900	51,100	51,500
D 9	3.0	53,100	47,500	77,300	77,300	66,100	66,100
D10	3.0	52,600	45,000	80,700	82,000	67,600	72,400
D11	1.0	48,500	45,500	48,500	49,400	46,700	47,100
D12	2.0	59,500	55,500	64,000	64,000	61,200	61,200
D13	1.0	41,500	34,000	33,500	38,800	30,400	32,500

See footnote bottom of Table 2.

TABLE 5—CRITICAL LOADS FOR PLATES OF VARIOUS THICKNESSES

Series E

Diameter of Roller 116 Inches

Annealed Steel Castings of Medium Grade

Test No.	Thickness of Plate	Critical Load from Lateral Flow *a*	Critical Load from Lateral Flow *c*	Critical Load from Longitudinal Flow *a*	*b*	*c*	*d*
E 1	1.5	33,000	29,800	35,000	35,000	32,400	32,400
E 2	1.0	28,100	24,000	29,300	29,300	26,300	26,300
E 3	2.5	28,000	22,500	52,200	54,700	46,000	49,000
E 4	2.0	30,800	25,000	45,500	45,500	40,500	40,500
E 6	0.5	20,000	17,500	18,600	18,600	11,500	11,500
E 7	1.0	30,000	26,400	29,900	29,900	25,000	25,000
E 8	0.25	15,500	12,200	14,000	14,000	9,300	9,300
E 9	0.25	15,900	13,100	14,800	14,800	11,000	11,000
E10	0.5	19,300	18,200	19,200	19,200	16,600	16,600
E14	1.87	30,400	25,000	40,600	41,200	35,600	38,500
E15	2.5	27,000	20,000	50,260	50,260	45,000	45,000
E16	1.5	27,700	21,000	33,000	33,000	29,000	29,000

See footnote bottom of Table 2.

Table 6—Critical Loads for Plates of Various Thicknesses

Series M

Diameter of Roller 356 Inches
Annealed Steel of Structural Grade

Test No.	*Thickness of Plate*	*Critical Load from Lateral Flow*		*Critical Load from Longitudinal Flow*			
		a	*c*	*a*	*b*	*c*	*d*
M1	2.5	62,500	58,000	70,000	70,600	63,500	63,500
M2	2.5	55,000	49,100	65,500	67,500	56,000	60,500
M3	2.0	55,000	52,400	57,200	59,200	53,700	54,400
M4	2.0	57,200	55,000	59,500	61,100	54,300	55,700
M5A	1.0	48,500	46,000	45,800	46,700	41,500	43,100
M5B	1.0	45,800	43,200	44,200	45,600	40,000	41,900
M6A	0.5	40,000	37,800	41,300	41,300	37,500	37,500
M6B	1.5	54,000	51,500	50,600	51,400	47,500	48,500

See footnote bottom of Table 2.

TABLE 7—CRITICAL LOAD FOR VARIOUS KINDS OF MATERIAL

Test No.	*Thickness of Plate*	*Diameter of Roller*	*Kind of Steel*	*Heat Treatment*	*Critical Load, Pounds per Inch Width of Plate* — *Lateral Flow*	*Longitudinal Flow*
F 5	1.5	236	Carbon Steel Casting Medium Grade	Annealed at Laboratory	42,500	41,600
F 6	1.5	236	Carbon Steel Casting Medium Grade	Annealed at Laboratory	44,000	43,600
C 41	1.5	236	Carbon Steel Casting Medium Grade	Annealed at Foundry	60,000	61,000
C 42	1.5	236	Carbon Steel Casting Medium Grade	Annealed at Foundry	59,000	61,000
C 41 HYL	1.5	236	Hylastic	Normalized at Foundry	105,000	102,000
C 42 HYL	1.5	236	Hylastic	Normalized at Foundry	105,000	110,000
L 7	1.5	236	Structural	Annealed at Laboratory	22,800	23,500
L 8	1.5	236	Structural	Annealed at Laboratory	17,000	21,100
L 4	1.5	356	Structural	Annealed at Laboratory	31,000	31,200
L 5	1.5	356	Structural	Annealed at Laboratory	27,000	27,500
M 6B	1.5	356	Structural	Annealed at Laboratory	51,500	47,500
F 3	1.5	356	Carbon Steel Casting Medium Grade	Annealed at Laboratory	53,900	52,100
F 4	1.5	356	Carbon Steel Casting Medium Grade	Annealed at Laboratory	53,700	53,900

Table 8

Physical Properties of Materials

Small Numerals Indicate Number of Tests Averaged

Specimen	Before Rolling					After Rolling				
	Ultimate Strength	Yield Point	Elongation in 2 inches	Reduction of Area	Brinell Number	Ultimate Strength	Yield Point	Elongation in 2 inches	Reduction of Area	Brinell Number
C 41	79,409 [2]	44,057 [2]	19.87 [2]	28.38 [2]	159	78,751 [4]	42,063 [4]	17.96 [4]	24.32 [4]	160
C42	79,663 [2]	42,953 [2]	26.27 [2]	29.17 [2]	158	78,147 [4]	40,000 [4]	18.02 [4]	25.92 [4]	154
C41 HYL	102,086 [2]	58,553 [2]	23.12 [2]	41.22 [2]	214	100,510 [4]	58,700 [4]	14.16 [4]	20.43 [4]	199
C42 HYL	104,491 [2]	56,774 [2]	22.55 [2]	44.35 [2]	208	103,839 [4]	61,041 [4]	19.50 [4]	35.7 [4]	205
D11	63,472 [2]	29,804 [2]	18.77 [2]	21.48 [2]	129	62,861 [4]	31,190 [4]	14.81 [4]	17.68 [4]	136
D13	65,277 [2]	29,228 [2]	22.43 [2]	25.61 [2]	129	62,391 [4]	29,492 [4]	10.93 [4]	12.54 [4]	136
E2	63,054 [2]	37,150 [2]	12.64 [2]	15.05 [2]	135	61,743 [2]	36,747 [2]	14.62 [2]	17.40 [2]	138
E12	62,992 [4]	37,925 [4]	12.64 [4]	15.93 [4]	127	Not Tested				
E13	63,000 [4]	34,475 [4]	13.05 [4]	17.46 [4]		Not Tested				
F3	64,389 [2]	31,532 [2]	23.31 [2]	29.11 [2]	129	59,756 [4]	33,100 [4]	23.58 [4]	34.16 [4]	128
F4	63,980 [2]	30,869 [2]	19.31 [2]	25.16 [2]	130	61,389 [3]	33,659 [3]	19.58 [3]	29.46 [3]	131
F5	64,450 [2]	32,278 [2]	24.37 [2]	32.34 [2]	130	62,453 [4]	33,964 [4]	28.94 [4]	42.63 [4]	128
F6	63,302 [2]	32,985 [2]	26.00 [2]	32.21 [2]	128	62,486 [3]	34,420 [3]	24.88 [3]	36.46 [3]	128
L4A	69,367 [3]	43,170 [3]	24.16 [3]	53.46 [3]	129	L 72,288 [3]	L 47,127 [2]	L 29.5 [3]	L 62.8 [3]	125
L5A	70,722 [2]	47,393 [1]	24.6 [2]	56.6 [2]	145	L 73,986 [3] T 70,051 [1]	L 51,552 [3] T 47,449 [1]	L 32.8 [3] T 23.6 [1]	L 62.2 [3] T 53.1 [1]	142
L7	51,934 [2]	24,834 [2]	34.3 [2]	55.8 [2]	101	T 53,000 [4]	T 26,440 [4]	T 31.4 [4]	T 49.8 [4]	105
L8	51,958 [2]	22,494 [2]	33.25 [2]	50.55 [2]	97	T 52,562 [4]	T 25,103 [4]	T 31.94 [4]	T 49.8 [4]	103
L9	50,220 [3]	31,377 [3]	34.85 [3]	52.3 [3]	99	L 54,370 [3]	L 34,428 [3]	L 38.67 [3]	L 49.8 [3]	109
M3	58,929 [2]	31,329 [2]	18.05 [2]	39.9 [2]	106	T 59,840 [4]	T 33,241 [4]	T 24.0 [4]	T 44.7 [4]	116
M6B	57,698 [2]	31,384 [2]	14.75 [2]	8.0 [2]	108	T 56,207 [2]	T 31,933 [2]	T 12.3 [2]	T 19.2 [2]	114

T: indicates tension specimen was taken TRANSVERSE to direction of rolling.
L: indicates tension specimen was taken PARALLEL to direction of rolling.

TABLE 8—*Continued*

Specimen	Before Rolling					After Rolling				
	Ultimate Strength	Yield Point	Elongation in 2 inches	Reduction of Area	Brinell Number	Ultimate Strength	Yield Point	Elongation in 2 inches	Reduction of Area	Brinell Number
A3	65,054 [2]	31,675 [2]	29.20 [2]	44.23 [2]	128					
A7	61,794 [2]	30,708 [2]	21.57 [2]	31.50 [2]	124					
A9	64,789 [2]	30,225 [2]	29.07 [2]	43.00 [2]	125					
B2	64,896 [2]	35,395 [2]	24.36 [2]	30.27 [2]	128					130
B5	64,549 [2]	35,705 [2]	26.96 [2]	36.53 [2]	130					132
F22	86,119 [2]	57,023 [2]	15.05 [2]	23.4 [2]	193					184
F24	84,210 [2]	56,000 [2]	16.62 [2]	26.5 [2]	188					174
F26	85,187 [2]	55,275 [2]	15.15 [2]	22.05 [2]	188					178
L1A	T 71,666 [2]	T 46,685 [2]	T 22.4 [2]	T 49.25 [2]	128					133
L3A	T 70,202 [2]	T 47,589 [2]	T 24.1 [2]	T 48.05 [2]	144					134
L8A	T 68,774 [2]	T 43,870 [2]	T 25.9 [2]	T 52.4 [2]	138					127
M2	L 58,409 [3]	L 29,737 [3]	L 37.23 [3]	L 59.73 [3]	107					117
M2	T 58,711 [3]	T 31,945 [3]	T 21.6 [2]	T 39.27 [3]	107					117
E3	66,349 [2]	34,725 [2]	19.6 [2]	24.0 [2]	143					148
E15	67,299 [2]	31,366 [2]	19.8 [2]	21.7 [2]	136					151

Table 9

Comparison of Proposed Design Load and Experimentally Determined Critical Load

Series (1)	Diameter of Roller (2)	Yield Point (3)	Thickness of Plate (4)	$P = [18000 + 120D] \left[\frac{p - 13000}{23000}\right]$ (5)	Proposed Design Load $\frac{2}{3}P$ (6)	Critical Load from Lateral Flow (7)	Critical Load from Longitudinal Flow (8)
E	116	34,533	1.0	29,877	19,918	25,200	25,650
		34,533	1.5	29,877	19,918	25,400	30,700
		34,533	2.0	29,877	19,918	25,000	38,050
		33,045	2.5	27,834	18,556	21,250	45,500
A	188	30,869	1.0	31,515	21,010	26,500	23,250
			1.5			24,050	29,650
			2.0			33,050	35,850
			2.5			23,100	46,900
			3.0			29,000	52,750
F	116	31,900	1.5	26,238	17,492	31,000	32,000
	236	32,600	1.5	39,465	26,310	43,000	42,500
	356	31,200	1.5	48,030	32,020	54,300	52,700
	476	31,900	1.5	61,749	41,165	66,000	63,300
F Hardened	236	56,000	1.5	86,618	57,745	80,000	70,000
	356	57,023	1.5	116,218	77,478	105,000	100,000
	476	56,500	1.5	142,075	94,716	149,500	142,500
L	116	31,377	1.5	25,504	17,000	22,500	24,000
	236	23,664	1.5	21,925	14,616	19,900	22,250
	356	23,664	1.5	28,174	18,782	28,950	29,250
	476	23,664	1.5	34,856	23,237	31,000	30,975
LA	116	45,631	1.5	45,294	30,196	47,200	45,550
	236	45,380	1.5	65,219	43,479	73,750	63,750
	356	46,685	1.5	88,955	59,303	88,750	82,250
M	356	31,219	1.0	48,090	32,060	44,600	40,750
			1.5			51,500	47,500
			2.0			53,700	54,000
			2.5			53,550	59,750
D	356	29,516	1.0	43,597	29,064	39,375	38,150
			2.0			52,325	57,450
			3.0			50,200	71,925
B	476	35,550	2.0	73,618	49,079	78,300	72,750
			3.0			84,950	86,600
			4.0			70,650	85,150
C	236	43,505	1.5	61,420	40,196	59,500	61,000
CHYL	236	57,663	1.5	89,953	59,968	105,000	106,000

Appendix F

(10) PUNCHED AND REAMED WORK

F. O. Dufour, Chairman, Sub-Committee; Thos. Earle, G. H. Gilbert, G. A. Haggander, Albert Reichmann, A. F. Robinson, G. H. Tinker, F. P. Turner, W. L. Wilson.

At the Convention held March, 1928, this Committee recommended: That Article XII, Workmanship, in General Specifications for Steel Railway Bridges, as issued August, 1925, Third Edition, be revised and received as information (See Appendix A—Report of Committee on Iron and Steel Structures—Proceedings Vol. 29, Page 367).

We present the following report and recommend it be received as information:

In the Proceedings of the Fourth Annual Convention of this Association, Vol. 4, March, 1903, the Iron and Steel Structures Committee's report advised that "it is the intention of the Iron and Steel Structures Committee to make a series of experiments to determine the safe limit of plain punching and the amount of reaming needed to remove the injured metal when the said safe limit has been passed."

This same report contained a compilation "of published and unpublished information on the subject and drew conclusions from the compiled data"—pages 195 to 226; but it is not clear that they ever carried out the intentions as to make tests until 1923, twenty years afterwards.

Of all the information published those tests made by the Edgemoor Iron Company in 1884 and 1893 with punched, reamed and drilled specimens and those by the Bridge and Building Department of the Chicago, Milwaukee & St. Paul Railway are perhaps the most important and significant.

The Committee at that time circularized the roads as to their practice in punching and reaming and the replies of the twenty-two railroads answering is tabulated as follows:

Table I—Punching and Reaming Practices, 1903

Railroad	*Ream*	*Punch*	*Remarks*
C. & E. I.	Main member		Punch bracing and unimportant details
St. L. & S. F. R.	Medium steel	Soft steel	
M. K. & T. Ry.	In favor of it		
Cin. Sou Ry.	All		
B. & O.	Above 5/8		
N. Y. C. & H. R.	All except laterals		
K. C. So.	Medium steel	Soft steel	
C. & N. W.	Medium steel	Otherwise	Ream soft in tension members and flanges and web. Otherwise punch.

Railroad	*Ream*	*Punch*	*Remarks*
L. & N.	Medium steel		
C. C. C. & St. L.	Soft over ⅝		Otherwise punch
I. C. R. R.	Medium ½" or over		Otherwise punch
P. & R. Ry.	Medium and soft over ¾"		Otherwise punch
Erie R. R.	All over ⅝		Otherwise punch
N. Y., N. H. & H.	All over 11/16		Otherwise punch
Pennsylvania	All over ⅝		Otherwise punch
C. B. & Q.	Everything		
C. R. I. & P.	Everything		
L. V. R. R.	All above ½		Otherwise punch
So. P.	Tension members, floor pl. grs. and all over ⅝"		Otherwise punch
N. & W.	Medium	Soft	
N. Y., C. & St. L.	Medium	Soft	
C. M. & St. P.	All main members	Bracing	

The conclusion to be drawn from this table is that reaming was nearly always required in the case of medium steel; and that where punching was allowed a ⅝ in. thickness was the limit.

The 1884 Edgemoor Tests of Heisler's consisted of 75 tests each on Basic and acid open hearth and Bessemer steels. Only the open hearth will be given.

The specimens were 8 in. or 12 in. wide and varied in thickness from ¼ to ¾ in., inclusive, varying by ⅛ in. It was said to have been "soft steel"; but the fact that the ultimate was over 55,000 lb. and the elastic limit over 30,000 lb. and a reduction of area of about 60 per cent shows it to have been what we now designate as a medium steel. The size of the holes was not stated, nor is the amount of reaming; but it is supposed that holes were punched 15/16 in. in diameter and when reamed they were punched 11/16 and reamed to 15/16.

The individual tests on the various sizes were not stated, only the averages of the different classes of steel. In the following Table II the Basic and Acid tests are averaged, 150 tests in all.

TABLE II—RESULTS 1884 EDGEMOOR TESTS

Operation	*Ultimate Strength*	*Elastic Limit*	*Reduction of Area*	*Elongation*
Plain Specimens	56,718	33,596	58.6	Not given
Punched % change.......	—3.78	+23.33	—50.91	Not given
P. & R. change..........	+6.85	+20.53	—15.05	Not given
Drilled change	+6.25	+22.55	—10.66	Not given

The tests of the Sub-Committee of Committee XV were made on medium open hearth steel and consisted, with few exceptions, of specimens of each thickness 3 in. or 3½ in. wide and this thickness varied in from ⅜ in. to 1⅛ in. In all 249 tensile tests were made. Table III averages compiled from the results of these tests is comparable with Table II.

TABLE III—RESULTS A.R.E.A. TESTS

Operation	*Ultimate Strength*	*Elastic Limit*	*Reduction of Area*	*Elongation*
Plain Specimens	61,279	36,861	46.4%	33.4%
Punched	—8.15	+15.85	—64.0	—82.5
Punched and Reamed.....	+1.82	+11.60	—31.3	—65.0
Drilled	—9.20	+ 5.39	—23.5	—63.0

The results show no discrepancies for the following reasons:

1. Table II steel is softer than that in Table III.

2. The holes of the work in Table II are all $\frac{15}{16}$ in., while those in the work of Table III vary from $\frac{15}{16}$ to $1\frac{3}{16}$.

3. The material in Table II varies from ¼ in. to ¾ in. in thickness; that in Table III from ⅜ in. to 1⅛ in.

4. The specimens in Table II were 8 in. and 12 in. in width; those in Table III were 3 and 3½ in.

Both Tables show the same results. These are:

1. That the punching greatly reduces the reduction of area and elongation.

2. That all operations change the ultimate strength slightly, increase the elastic limit, and decrease the elongation considerably.

3. The sub-punching and reaming has practically the same effect as drilling.

Attention is now called to the fact that the real measure of comparison of reduction of area and elongations is *not plain material* but drilled material. The punched, reamed and drilled specimens have a form so different from that of the plain specimen that some of the reduction in both area and elongation from that of the plain specimen is due to it. The true comparison is, therefore, with the drilled specimens whose form is not only similar in all cases but practically the same in most cases. Since the results in Table III are averages of averages and the speed of the machine when the material was past the elastic limit was not the same in all cases the results in the case of ultimate strength are not significant. Also it must be remembered that all specimens are not from the same heat.

The reduction of area and the elongation are, however, very significant.

In order to study the effect of the several operations and the form of the specimen several specimens of punched and several of sub-punched and reamed work had the middle portion machined out. The sides were then tested. The tests were few in number, 10, and, therefore, not conclusive, but the results showed in general slight increases in the ultimate and elastic limits. In the case of punched work the difference between the reduction of area as shown by the 3-hole specimens and these is not marked, but in the case of sub-punched and reamed work it was practically the same as for the plain specimens.

The elongation as indicated by these special specimens was about double that of the three-hole specimens.

More tests with this type of specimen will be required before conclusions other than they plainly show that sub-punched and reamed work is preferable to punched work.

All tensile specimens had 3 holes 3 in. or 3½ in. apart, and were sufficiently long to take the grips of the testing machine which was uniformly run at 0.115 in. per minute until the elastic limit was well past and then about 2 in. per minute.

Tables IV and V show the effect of the several operations on the yield point and ultimate strength of metal of various thicknesses. The conclusions to be reached are:

1. That punching raises the yield point and lowers the ultimate.
2. The sub-punching and reaming and also drilling raises both the ultimate and the elastic limit.

Table IV—Yield Point, Lb. Per Sq. In.

	⅜"	½"	⅝"	¾"	⅞"	1"	1⅛"
P 15/16	......	33,900	......	48,120	......	49,620	......
P 1/16	41,560	36,685	38,425	47,420	47,280	45,233	38,700
P 11/16, R 15/16...	35,910	32,796 33,298	37,400	48,900 49,740	48,540	46,660 45,920	......
P 13/16, R 1 1/16..	40,470	41,488	36,000	47,380	42,660	39,700	40,225
P 11/16, R 1 1/16..	38,350	36,200	36,650	32,700	47,300	43,100	42,530
P 11/16, R 1 3/16..	39,300	35,200	36,500	40,400	53,150	45,100	41,050
Drilled 15/16 ...	37,300	34,300	37,650	32,800	47,000	40,300	35,550
Plain	37,500	34,850	34,250	37,600	38,600	38,365	......

Table V—Ultimate Strength, Lb. Per Sq. In.

	⅜"	½"	⅝"	¾"	⅞"	1"	1⅛"
P 15/16	......	51,156	......	65,440	......	61,240	......
P 1 1/16	58,420	54,902	48,550	60,190	62,200	52,800	48,060
P 11/16, R 15/16...	56,560	52,340 52,160	62,120	73,520 72,720	73,740	74,100 74,400	......
P 13/16, R 1 1/16..	65,340	60,975	63,420	71,870	72,540	65,980	65,140
P 11/16, R 1 1/16..	56,250	57,450	59,000	52,100	63,600	58,150	57,645
P 11/16, R 1 3/16..	56,830	57,790	62,850	52,500	64,850	58,580	57,200
Drilled	57,750	56,500	58,000	51,030	61,300	56,200	48,800
Plain	57,350	55,300	57,100	65,425	67,500	67,700	......

Tables VI and VII show the effect of the several operations on the reduction of area and on the elongation. The conclusions are:

1. All operations decrease both elongation and reduction of area; punching more than the others, and increasing with the thickness.
2. Sub-punching and reaming is as efficient as drilling.
3. In the case of sub-punching and reaming and also drilling the effect on both reduction of area and elongation does not vary with the thickness.

TABLE VI—TENSION TESTS, REDUCTION OF AREA AVERAGE

3 Holes	Reduction of Area in Percentage 3/8"	1/2"	5/8"	3/4"	7/8"	1"	1 1/8"
P 15/16	31	26	24	16	15	4	....
P 1 1/16	20	20	20	18	18	4	3
P 11/16, R 15/16	34	39	34	28	24	20	....
P 13/16, R 1 1/16	27	33	28	26	29	20	27
P 11/16, R 1 1/16	24	29	28 1/2	37 1/2	35	38	37 1/2
P 11/16, R 1 3/16	26	29	37 1/2	48	33 1/2	37 1/2	39 1/2
Drilled 15/16	24	36 1/2	35 1/2	38 1/2	37 1/2	44	33 1/2
Plain	52	55	51	49	49	42	....

TABLE VII—TENSION TESTS—ELONGATION AVERAGE

3 Holes	Elongation in Percentage 3/8"	1/2"	5/8"	3/4"	7/8"	1"	1 1/8"
P 15/16	10	10	8	6	6	2 1/2	....
P 1 1/16	4 1/2	6 1/2	4 1/2	5	5	3 1/2	1
P 11/16, R 15/16	12	14	11	12	12	9	....
P 13/16, R 1 1/16	8 1/2	11	11 1/2	11	11 1/2	9 1/2	11
P 11/16, R 1 1/16	9	9 1/2	11	12	12	13	13 1/2
P 11/16, R 1 3/16	9	10 1/2	10	13 1/2	12	12 1/2	13
Drilled 15/16	11 1/2	11 1/2	10	12	13	14 1/2	14 1/2
Plain	35	38	38	33	34	31	....

Bend Tests

A total of 144 bend tests was made. These specimens were either 9 in. by 3 1/2 in. or 12 in. by 3 in. and varied by 1/8 in. from 3/8 in. to 1 1/8 in. in thickness .

A few were tested as beams with 8 in. spans and the deflections measured with Ames gages reading to one ten-thousandth of an inch, see Fig. 1.

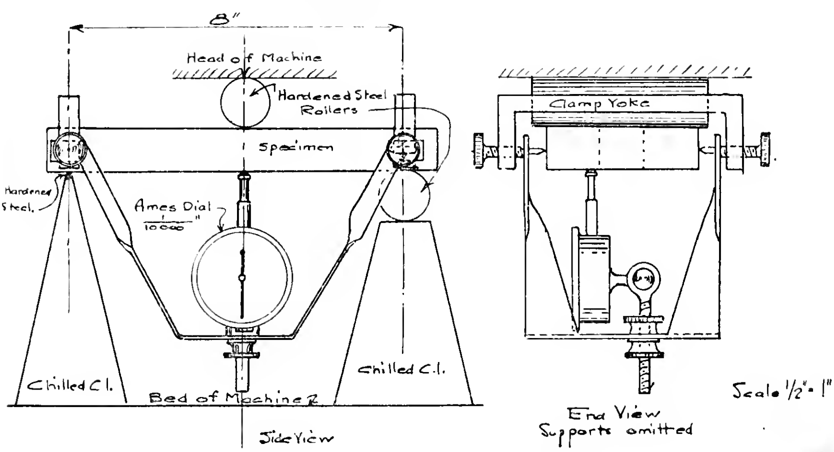


FIG. 1—MICROMETER DEFLECTOMETER

Plates I to IV show typical results. When the "fin" side, or side the punch came out, was up the curves showed a well defined yield point. When the "fin" side was down failure with punched work started at about 1/2 the yield point shown with "fin" up, while sub-punched and reamed work showed up more favorably. Apparently this was due to the opening up of incipient cracks due to the punching operation. The tests on reamed specimens were only made where ⅛ in. of the metal was reamed out. If a greater amount had been reamed out, say ¼ in., possibly no difference between fin up and fin down would have developed.

Specimens which had been slightly bent as beams and others were tested by bending about a mandrel in accordance with the A.S.T.M. standards. One of each thickness was bent with the fin up and one with the fin down and compared with bent plain specimens. As soon as an incipient crack was detected the bending was stopped and the angle through which it had been bent was measured. Plates V to IX and Tables VIII and IX show the results.

TABLE VIII—BEND ANGLES (FIN UP)

	Angle of Bend in Degrees							
Holes	⅜″	½″	⅝″	¾″	⅞″	1″	1⅛″	*Remarks*
P $\frac{15}{16}$	142	89	148	63	..	16	..	Seems to in-
P $1\frac{1}{16}$	155	105	82	..	42	..	9	dicate that
P $\frac{11}{16}$, R $\frac{15}{16}$	177	165	175	80	..	47	..	P $\frac{13}{16}$, R $1\frac{1}{16}$
P $\frac{13}{16}$, R $1\frac{1}{16}$	180	107*	160	..	99	..	75	is equal to
P $\frac{11}{16}$, R $1\frac{1}{16}$	150	81	73	63	68	55	86	drilling.
P $\frac{11}{16}$, R $1\frac{3}{16}$	119	76	88	110	74	59	84	
Drilled $1\frac{1}{16}$	180	111	105	126	91	96	62	
Drilled $1\frac{3}{16}$	180	129	99	180	108	74	72	

*Slipped out at the machine with no crack. Underscored indicates results from split specimens.

TABLE IX—BEND ANGLES (FIN DOWN)

	Angle of Bend in Degrees						
Holes	⅜″	½″	⅝″	¾″	⅞″	1″	1⅛″
P $\frac{15}{16}$	118	53	100	34	..	17	..
P $1\frac{1}{16}$	145	53	39	..	55	..	8
P $\frac{11}{16}$, R $\frac{15}{16}$	145	180	150	114	..	49	..
P $\frac{13}{16}$, R $1\frac{1}{16}$	174	177	166	..	120	..	87
P $\frac{11}{16}$, R $1\frac{1}{16}$	116	74	80	62	61	47	80
P $\frac{11}{16}$, R $1\frac{3}{16}$	105	..	81	88	64	64	71
Drilled $1\frac{1}{16}$	108	81	90	76	78	67	55
Drilled $1\frac{3}{16}$	110	88	87	84	75	88	55

Underscored indicates results of tests from split specimens.

Obviously on account of the difficulties in determining just when the incipient crack started the bend angles are not exact. However, the results are significant as they clearly show the brittling effects of the work done on the piece.

The conclusions to be drawn are:

1. That punching effects more than drilling or sub-punching and reaming.

2. That the thicker the metal the greater is the effect of the several operations.

3. That the effect of punching on some of the thick specimens was so great that they broke in two at a bend angle of less than 10 degrees.

Hardness Tests

In all nearly 2000 hardness tests were made with a Rockwell Hardness machine. Specimens had the surfaces planed and were cut across through the hole diameter. Hardness tests were taken radiating from the center of the piece on both the axes of the specimen on both the "fin" and "non-fin" side. Tests were also taken on a medial line of the cross-section. All were started at $\frac{1}{16}$ in. from the hole and at intervals of $\frac{1}{8}$ in. apart up to 1 in. from the edge of the hole. Another test was made at the edge of the specimen. Plates X and XI show the results and Plate XII gives the relation between hardness and unit tensile stresses. Fig. 3, 4 and 5 are photos of some of the test pieces.

One series of tests was made to determine the variation over the cross-section. Fig. 2 shows the results. This indicates:

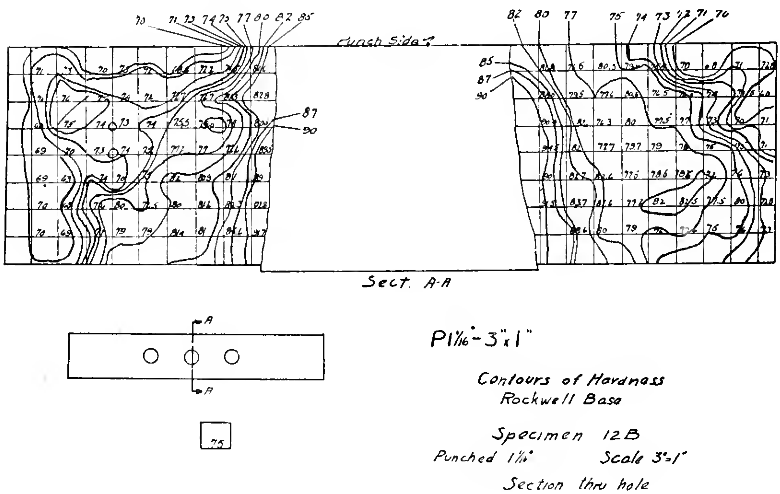


Fig. 2

1. That the hardness next to the hole was increased nearly 30 per cent, and

2. That it was greater near the fin side and greatest about midway of the thickness.

The values obtained $\frac{1}{16}$ in. from the edge of the hole were in some few cases not consistent. This was due to the bulging of the hole wall.

The results of the hardness tests show:

1. That punching and the $P\frac{11}{16}$ and $R\frac{15}{16}$ produce a zone of hardness, a maximum at the hole and practically zero at a distance from the edge equal to $\frac{1}{2}$ the thickness of the metal.

FIG. 3

A

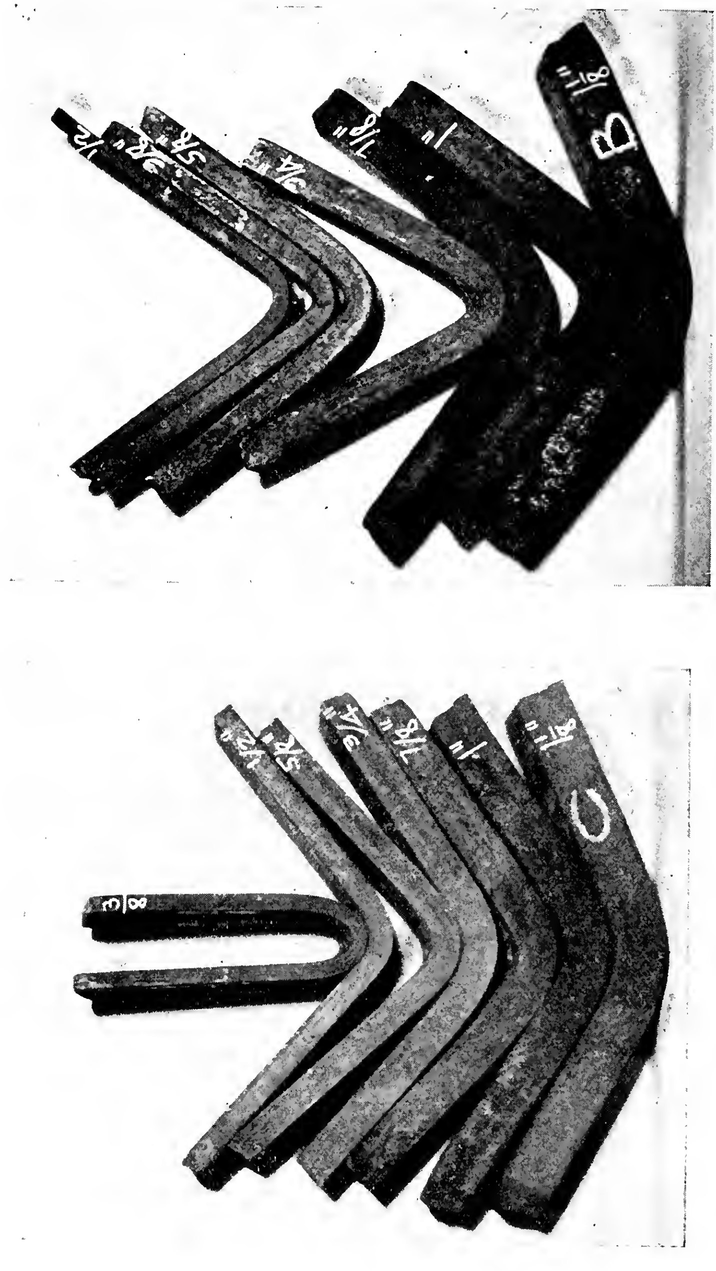


Fig. 4

Fig. 5

2. That drilled and also sub-punched and reamed work where over $\frac{1}{8}$ in. is reamed out is unaffected.

3. That material under $\frac{3}{4}$ in. in thickness was not materially affected.

Micro-Photos

Micro-photos were made as indicated in Fig. 6.

Fig. 7 shows how the punching disturbs the crystals. Fig. 8 indicates that the drilling does not disturb the crystals, and Fig. 9, sub-punched $\frac{11}{16}$ in. and reamed to $1\frac{1}{16}$ in., and Fig. 10, sub-punched $\frac{11}{16}$ in. and reamed to $\frac{15}{16}$ also, show that the crystals are not disturbed. Magnification was 100 in all cases and all studies were made on material $\frac{3}{4}$ in. thick.

Distortion was taken with micrometer microscopes, and the angle of cleavage made with the direction of the fabricating operation was likewise measured with microscopes.

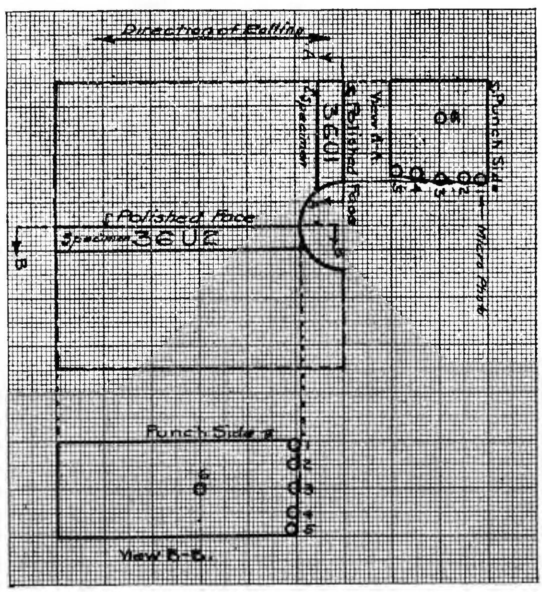


Fig. 6—Location of Micro Test Specimens and Photographs

From the microscopic studies the following results were obtained:

1. That the drilled bars have only a slight rotary distortion which extends to a maximum depth of .01 in.

2. That the punched bars suffered the greatest distortion. In no case, though, did this extend deeper than .16 in.

3. That sub-punched and reamed bars have suffered this same deformation, but that this deformation has been effectively removed by reaming $\frac{1}{8}$ in. from the sides of the hole. A small rotary distortion similar to that of drilling remains.

4. That in all cases the longitudinal sections have suffered more distortion than the transverse sections.

5. That any manner of cutting steel gives small deformation if no accompanying tearing of the metal results.

6. Plastic flow in steel before rupture is of greater extent in direction of rolling than across it.

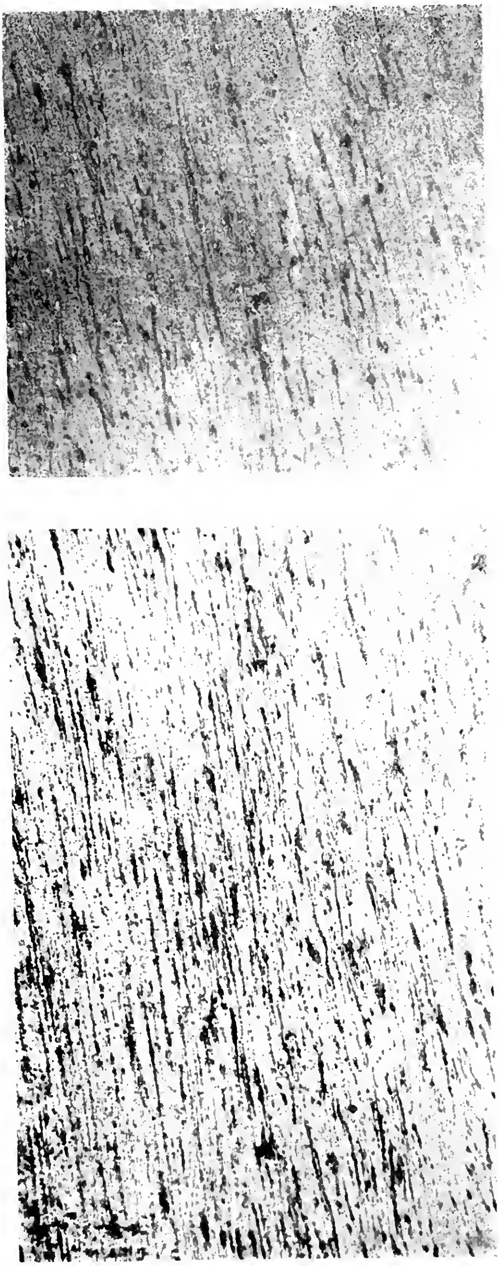


FIG. 7

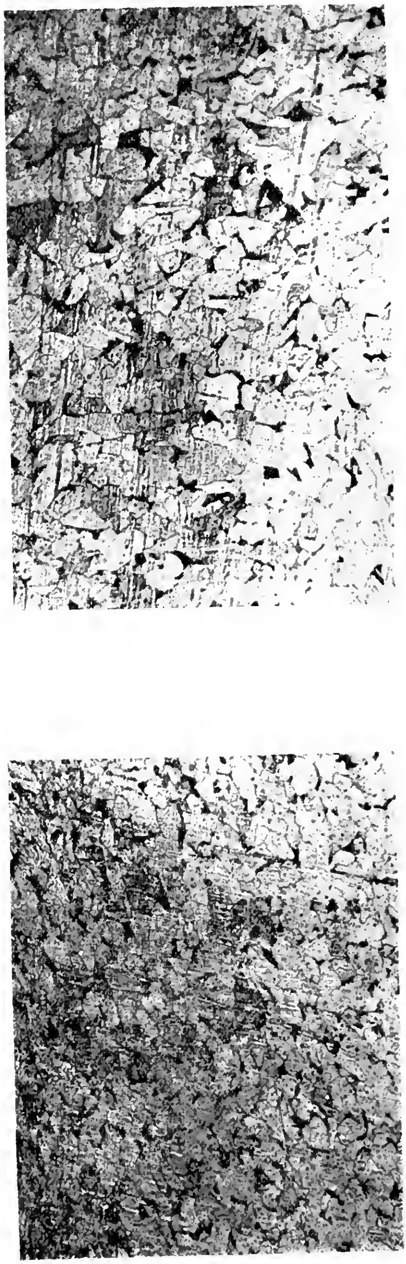


FIG. 8

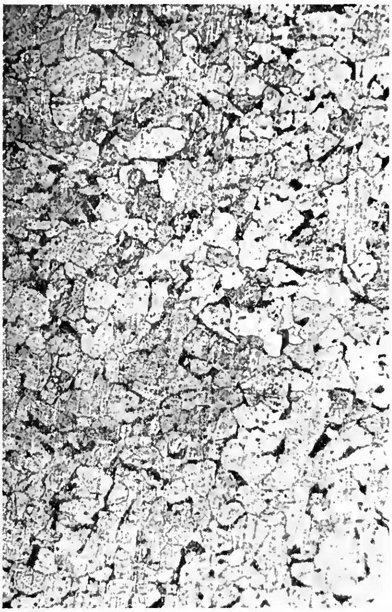
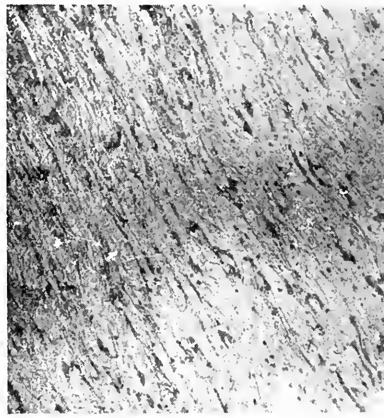


Fig. 9



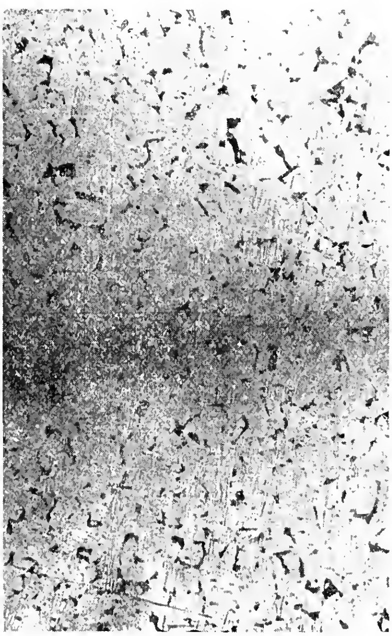


Fig. 10

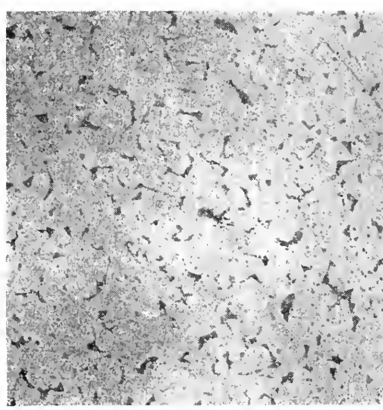


Fig. 11

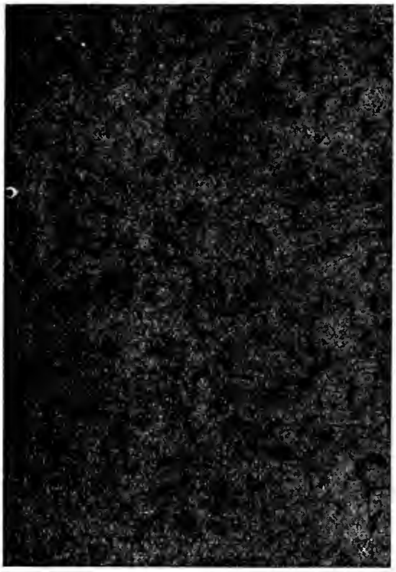


Fig. 12

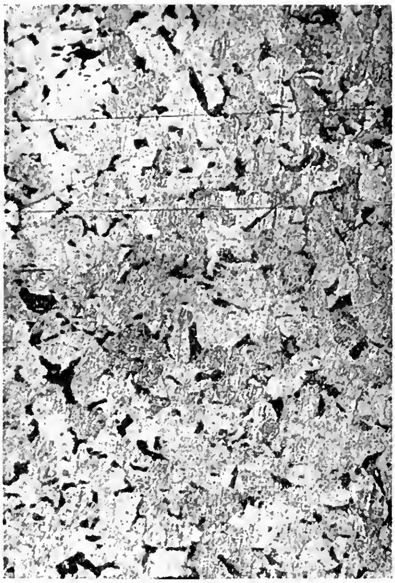


Fig. 13

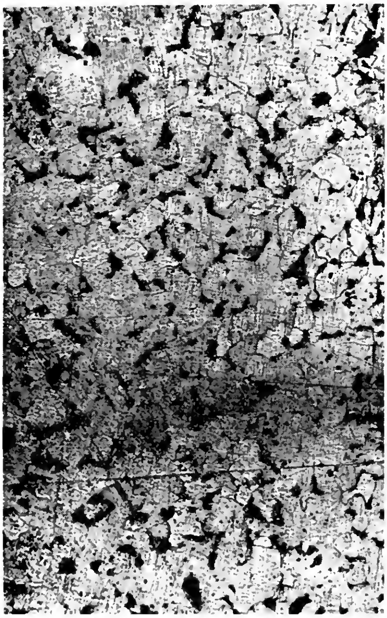


Fig. 14

Fig. 15

Plate I

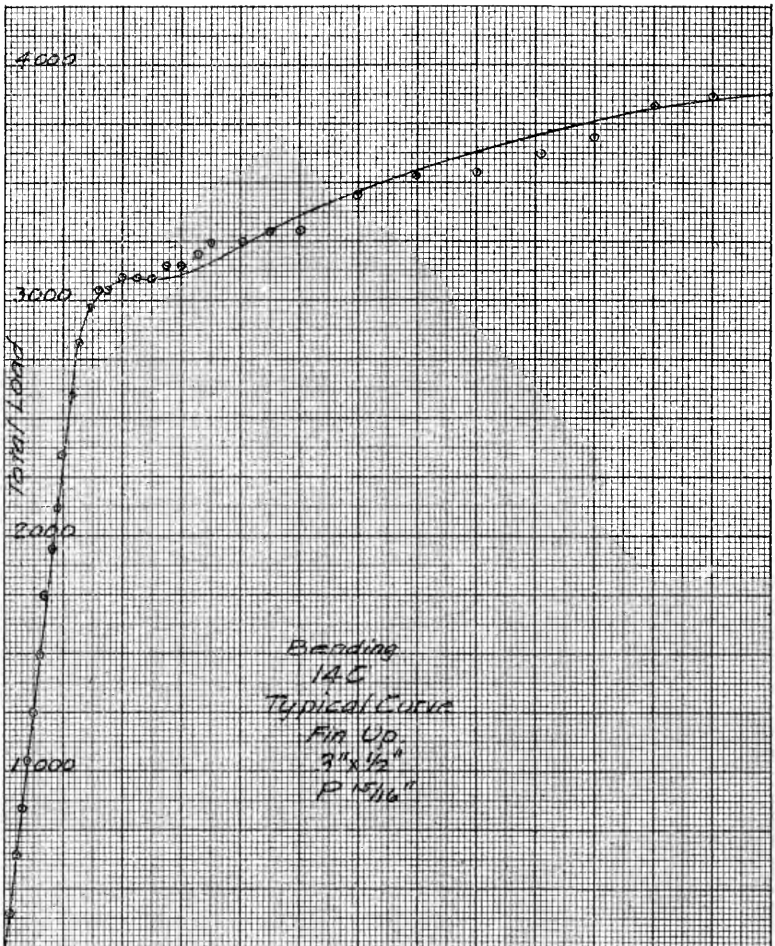

4000
3000
2000
1000
Total Load
Bending
14C
Typical Curve
Fin Up
3"x½"
P 15/16"
Deflection in Inches
0
.02
.04
.06
.08
.10
.12
.14
.16
.18
.20
.22
.24
.26

Plate II

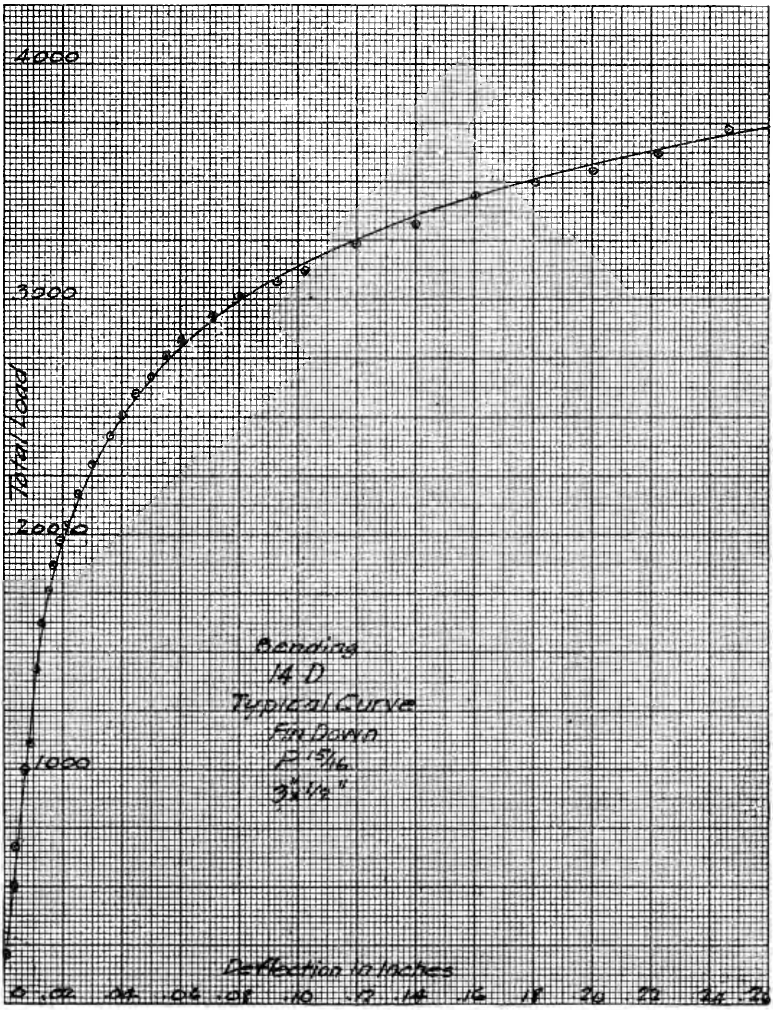

4000
3000
2000
1000
Total Load
Bending
14 D
Typical Curve
Fin Down
Deflection in Inches
0 .02 .04 .06 .08 .10 .12 .14 .16 .18 .20 .22 .24 .26

Plate III

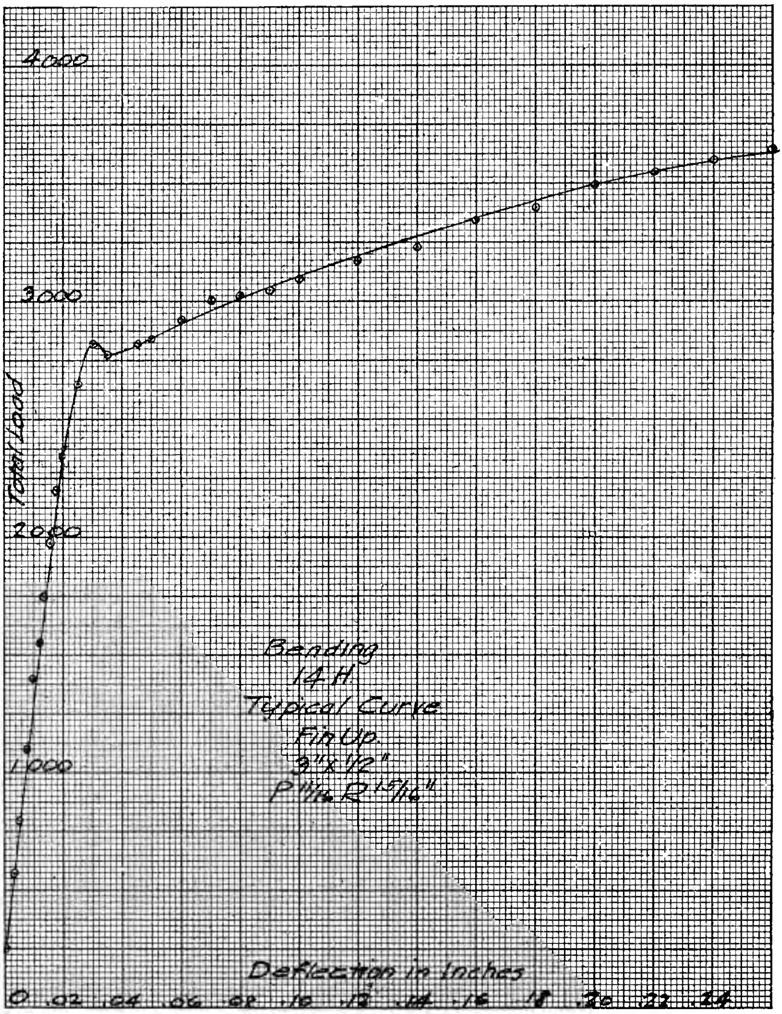

4000
3000
2000
1000
Total Load
Bending
14 H.
Typical Curve
Fin Up.
3"x 1/2"
P 11/16 R 15/16"
Deflection in Inches
0 .02 .04 .06 .08 .10 .12 .14 .16 .18 .20 .22 .24

Plate IV

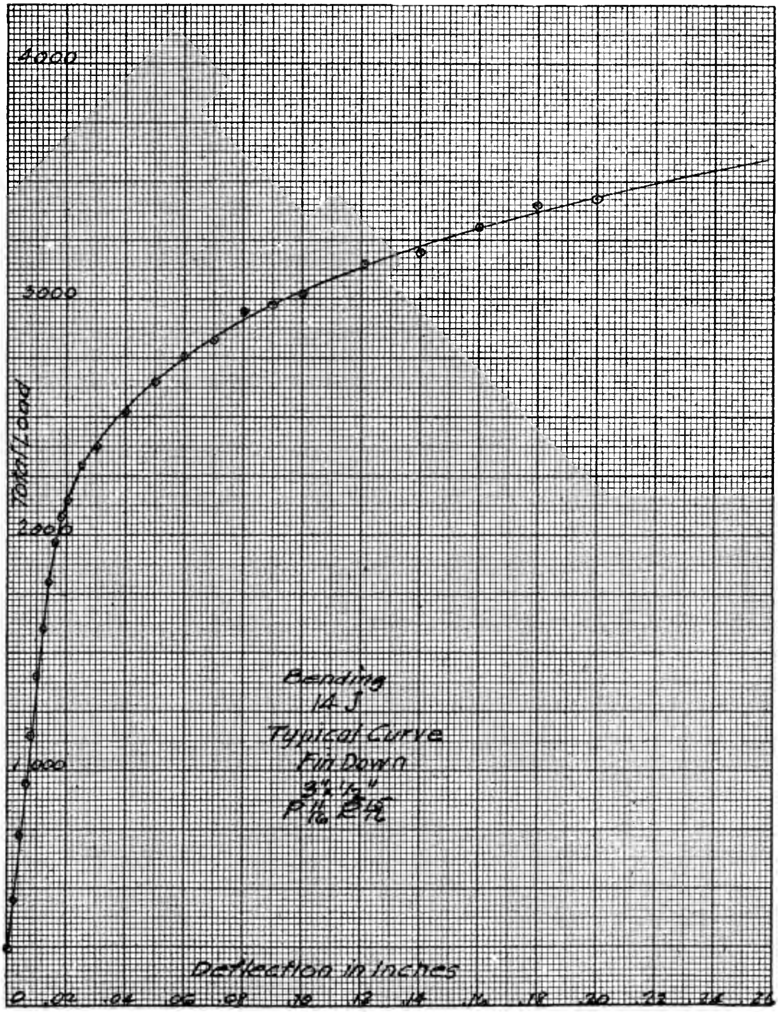

4000
3000
2000
1000
Total Load
Bending
14 J
Typical Curve
Fin Down
Deflection in Inches
0
.02
.04
.06
.08
.10
.12
.14
.16
.18
.20
.22
.24

Plate V

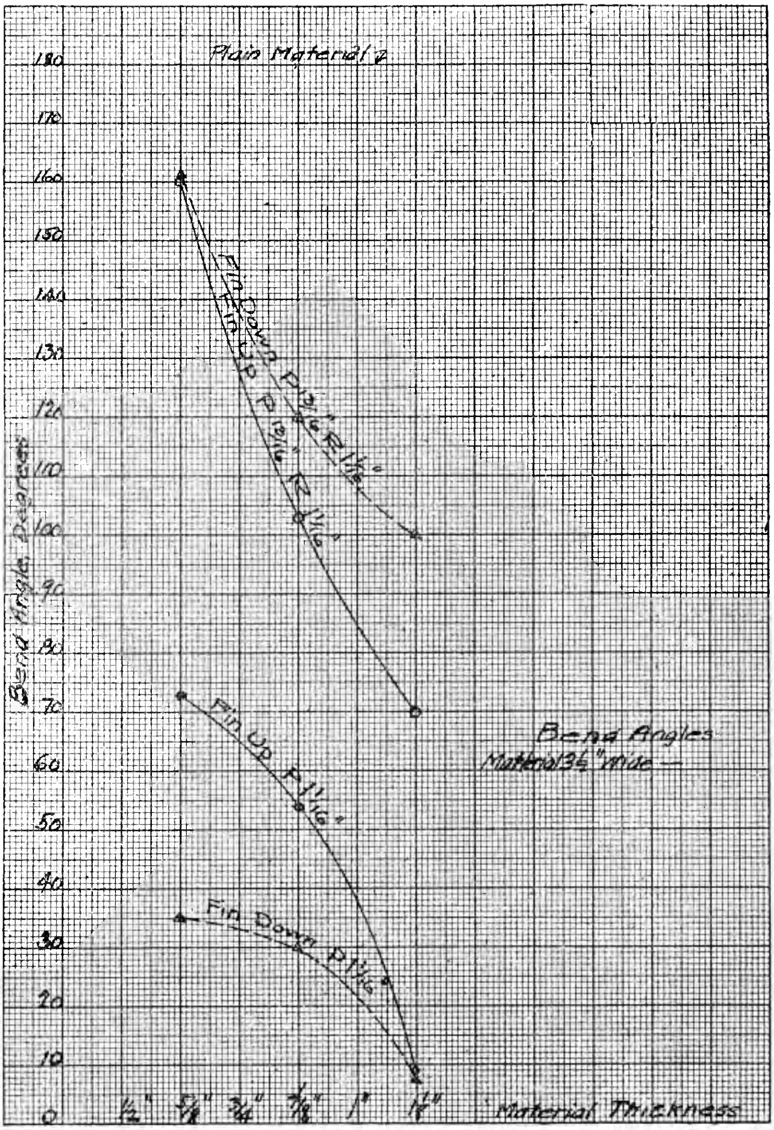

Plain Material
Bend Angle Degrees
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1/2"
5/8"
3/4"
7/8"
1"
1 1/8"
Material Thickness
Fin Down P 13/16" R 1 1/16"
Fin Up P 13/16" R 1 1/16"
Fin Up P 1 1/16"
Fin Down P 1 1/16"
Bend Angles
Material 3 1/2" wide —

Plate VI

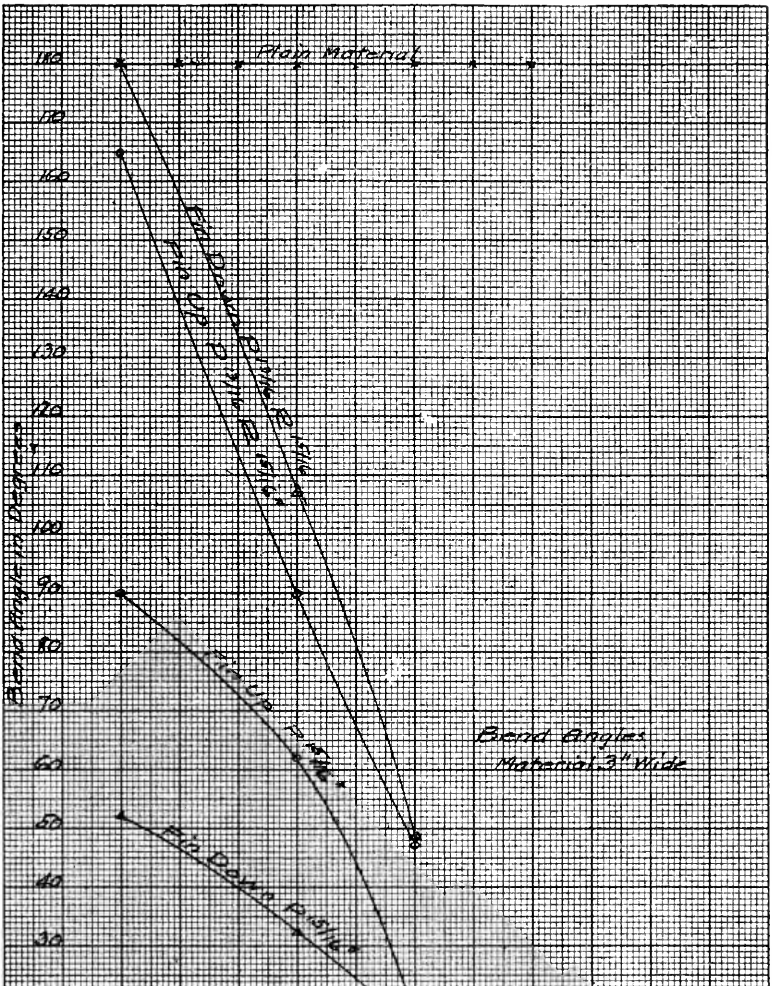
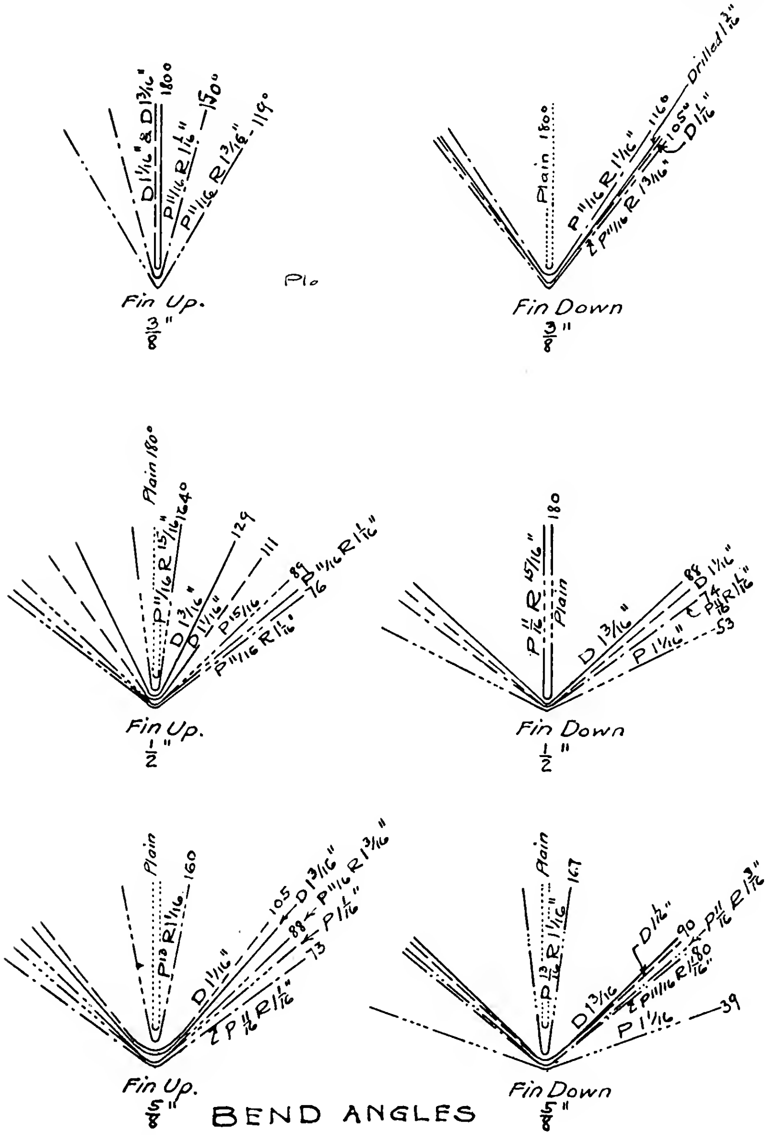
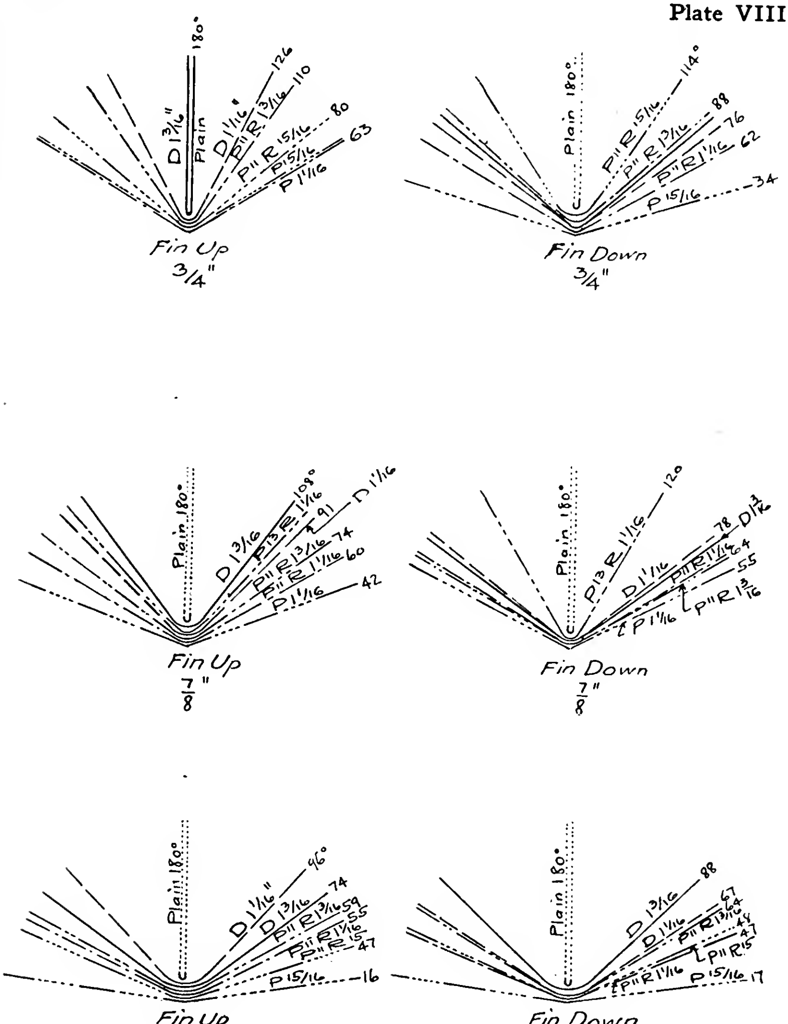

Plain Material
Fin Down R 1/16 R 15/16
Fin Up R 13/16 R 15/16"
Fin Up R 15/16
Fin Down R 15/16"
Bend Angles
Material 3" Wide
Bend Angle in Degrees
Material Thickness
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
3/8"
1/2"
5/8"
3/4"
7/8"
1"
1 1/8"

Plate VII



BEND ANGLES

Plate VIII



BEND ANGLES

Plate IX

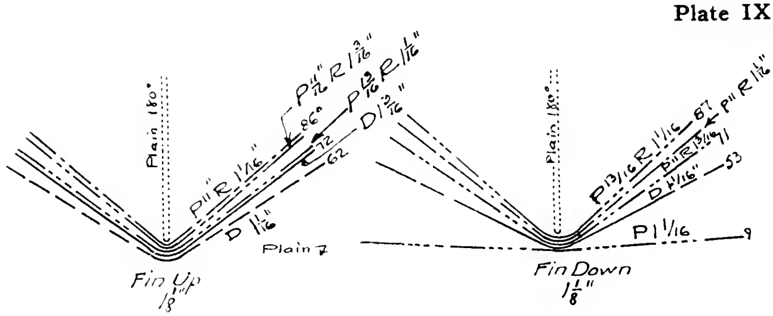


Plate X

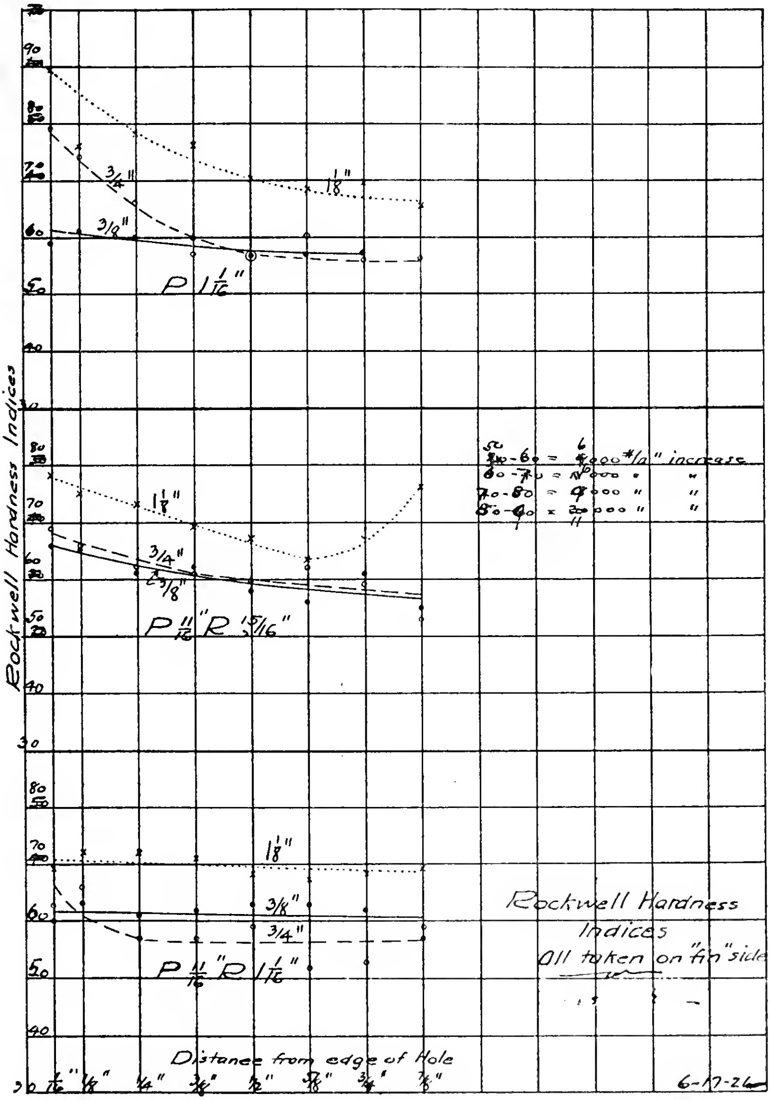

Rockwell Hardness Indices
P 1 1/16"
1 1/8"
3/4"
3/8"
P 11/16" R 15/16"
P 11/16" R 1 1/16"
Rockwell Hardness Indices
All taken on "fin" side
Distance from edge of Hole
6-17-26

Plate XI

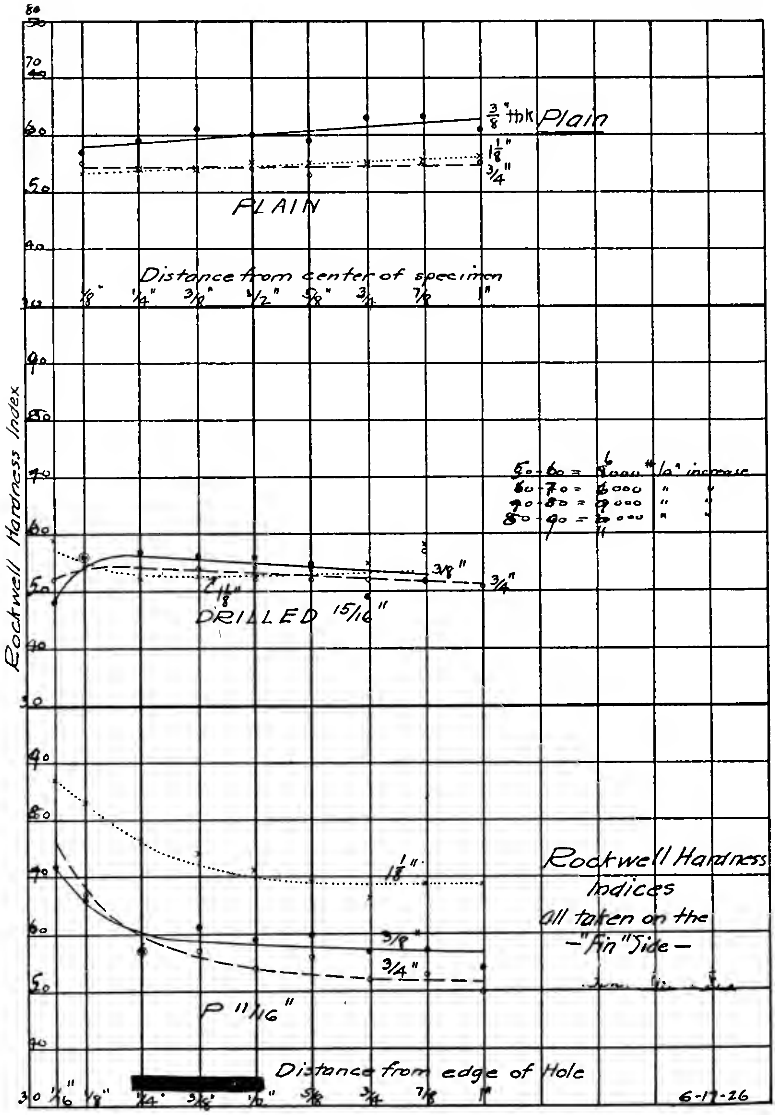
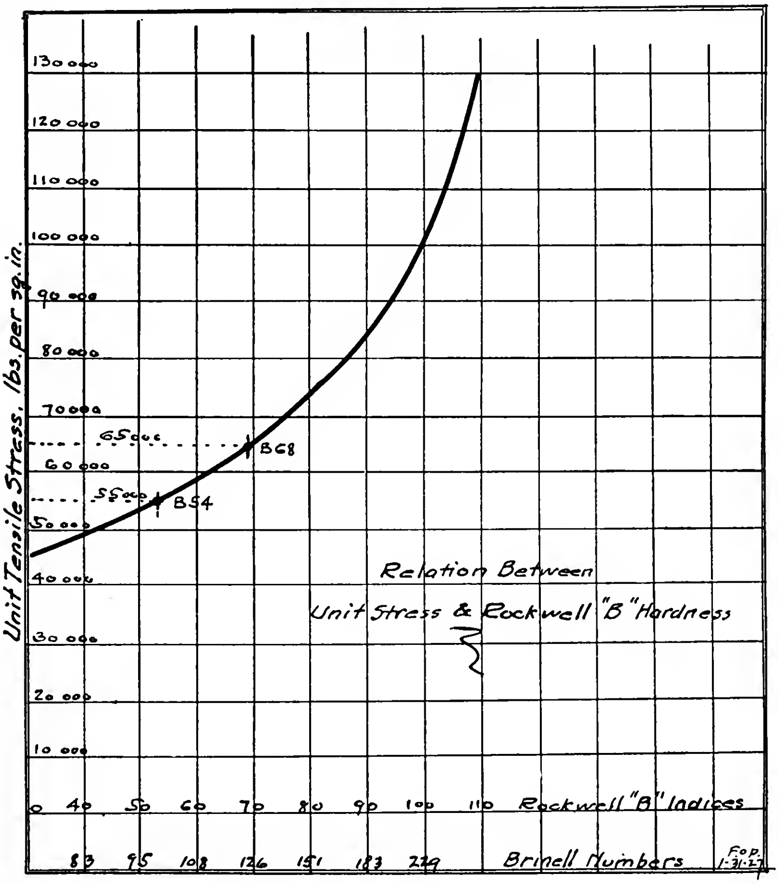

Rockwell Hardness Index
3/8" thk Plain
1 1/8"
3/4"
PLAIN
Distance from center of specimen
1/8" 1/4" 3/8" 1/2" 5/8" 3/4 7/8 1"
3/8"
3/4"
1 1/8"
DRILLED 15/16"
1 1/8"
3/8"
3/4"
P 11/16"
Rockwell Hardness Indices All taken on the -"Fin" Side-
Distance from edge of Hole
[redacted]
6-17-26

Plate XII



Unit Tensile Stress, lbs. per sq. in.
130 000
120 000
110 000
100 000
90 000
80 000
70 000
65 000
60 000
55 000
50 000
40 000
30 000
20 000
10 000
B68
B54
Relation Between
Unit Stress & Rockwell "B" Hardness
0 40 50 60 70 80 90 100 110 Rockwell "B" Indices
83 95 108 126 151 183 229 Brinell Numbers
F.O.P. 1-31-27

Other studies with the micrometer microscope on ¾-in. material indicate the following:

1. That the size of the punch (within commercial limits) does not affect the area of actual metal deformation to any extent.

2. That the greater the diameter of the punch, the more metal will be torn from the sides of the hole in passing through the bar.

3. That practically no metal is torn by punching, from the sides of the hole transverse to the direction of rolling; but the longitudinal section is very susceptible to tearing.

4. That the maximum distortion occurs about the place where the metal ceases to be cut clearly and starts to tear.

5. That there is practically no distortion where the drill, punch or reamer enters the bar.

Table X shows deformation measurements.

TABLE X—DEFORMATIONS

By Micrometer Microscopes

All Material ¾ In. Thick

Work	*Deformation in Inches*					*Maximum Deformation Inches*
	Location					
	1	2	3	4	5	
D $\frac{15}{16}$	.....	.....	.....	.....	.....	.....
D $\frac{15}{16}$	.....	.....	.....	.....	.....	.....
P $\frac{11}{16}$	.....	.0726	.104	.109	.0865	.111
P $\frac{11}{16}$	.0173	.0778	.128	.1178	.0795	.128
P $1\frac{1}{16}$	.....	.097	.1002	.109	.083	.111
P $1\frac{1}{16}$	.0276	.145	.121	.104	.0778	.152
P $\frac{11}{16}$, R $\frac{15}{16}$	.....	.....	.....	.....	.....	.....
P $\frac{11}{16}$, R $\frac{15}{16}$	.....	.0276	.0242	.045	.....	.0485
P $\frac{11}{16}$, R $1\frac{1}{16}$	.....	.....	.....	.....	.....	.....
P $\frac{11}{16}$, R $1\frac{1}{16}$	.....	.....	.....	.....	.....	.....

The complete log of tests together with many more photos, micro photos, and figures and plates is in the files of the Secretary and may be consulted there.

The entire results of tests would be more conclusive and more consistent if the test specimens had all been taken from material from the same heat. However, the following conclusions may be drawn:

1. That punching the metal makes it less ductile and raises the elastic limit an appreciable amount.

2. That the injurious effects of punching may be removed by reaming.

3. That sub-punching and reaming is as efficient as drilling.

Acknowledgment is made to Lafayette College, in whose testing laboratories the tests were made without charge to the Association.

Acknowledgment is also made to the Bethlehem Steel Company for furnishing specimens without charge to the Association.

*REPORT OF COMMITTEE XXII—ECONOMICS OF RAILWAY LABOR

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W. S. Burnett,
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H. A. Cassil,
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C. C. Cook,
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J. B. Mabile,
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G. M. O'Rourke,
J. C. Patterson,
F. S. Schwinn,
H. M. Stout,
G. M. Strachan,
W. H. Vance,
Cale Wamsley,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

1. Revision of the Manual.
2. Methods for securing greater efficiency and economy in the use of labor-saving devices in railway track maintenance (Appendix A).
3. Standardization of parts and accessories for railway maintenance motor cars (Appendix B).
4. Equating track values for labor distribution (Appendix C).
5. The economic ratio of supervision to labor (Appendix D).
6. Practical training and education of the individual workman in his assigned duties, as a means for securing an increased output and better quality of work, with less effort and fewer accidents (Appendix E).

Action Recommended

1. None.
2. That Appendix A be received as information, and the subject closed.
3. Continue for further study.
4. That conclusion (1) in Appendix C be approved for publication in the Manual, and the subject closed.
5. That Appendix D be received as information, and the subject closed.
6. That Appendix E be received as information, and the subject continued for further study.

Recommendations for Future Work

1. Revision of the Manual.
2. Continue the study of standardization of parts and accessories for railway maintenance motor cars.

*Bulletin 314, February, 1929.

3. Continue the study of practical training and education of the individual workman in his assigned duties, as a means for securing an increased output and better quality of work, with less effort and fewer accidents.

4. Analyze the operations of one or more roads that have made marked progress in the reduction of labor required for maintenance of way operations.

5. Investigate and report upon the methods of keeping cost data on maintenance of way operations, particularly those in vogue on the Chesapeake & Ohio Railway.

6. Study and report upon the organization of student camps and gangs recruited from college or university students in track and engineering work, similar to the plan followed by the Delaware and Hudson Company.

Respectfully submitted,

The Committee on Economics of Railway Labor,

A. N. Reece, *Chairman.*

Appendix A

(2) METHODS FOR SECURING GREATER EFFICIENCY AND ECONOMY IN THE USE OF LABOR-SAVING DEVICES IN RAILWAY TRACK MAINTENANCE

G. M. O'Rourke, Chairman, Sub-Committee; Wm. Carpenter, H. M. Church, J. F. Dobson, John Evans, C. S. Joseph, J. B. Mabile, F. J. Meyer, H. M. Stout.

During the past several years your Committee has conducted an investigation to determine the economies to be derived from the use of labor-saving devices. The study to date has included sixty types of machines and devices for saving labor.

Following the report of the Committee of 1918, the investigation was dropped until 1925. The work of the former was a brief description of machines and devices, while that of the latter was a detailed description of machines and operation, accompanied by tabulated data. In 1926 the study was confined to devices used in all subdivisions of ballast work —the distributing, cleaning, tamping and dressing of ballast. During 1927 consideration was given rail loading, laying and oiling devices; however, the data secured was so meagre, very few roads replying to the questionnaire, that a complete report could not be made.

Attention is directed to Conclusion 3 of the report of this Sub-Committee, appearing in the 1926 Proceedings, Volume 27, page 1045:

> "A large amount of the data from which this report was compiled was incomplete and showed a marked need of an accurate method by which cost data on labor items should be recorded."

A review of the cost of performing work with various labor-saving devices shows a considerable fluctuation in the unit cost of material handled or operation performed. These comparisons indicate the need of a satisfactory method of measuring and recording results obtained on different roads. However, there seems little doubt that the real cause of the difference in cost is due to one or more of the following conditions:

1. The different conditions under which the operation is performed, frequency of interruption, and restrictions imposed by traffic.
2. Character of material handled.
3. Capacity and condition of the machine performing the work.

Any or all of these conditions greatly influence the cost of performing work and the difficulty of making accurate comparisons of similar work performed on different roads. It, therefore, appears that a true comparison is the cost of performing the operation or work by any other economical method and the economy that may be effected by the use of the machine, compared with other methods of doing the work under like conditions. It is the recommendation of the Committee that railway operating and maintenance of way officers interest themselves in the economies of labor-saving machinery, as the data gathered will be enlightening, beneficial and well worth the effort.

During the past year investigation was made of methods for securing greater efficiency and economy by the use of the following labor-saving devices:

(1) Rail laying machines.
(2) Rail oiling devices (for preventing corrosion.)
(3) The advantages of operating in pairs or in multiple units, machines such as ditchers, rail loaders, ballast cleaners, etc.
(4) Labor-saving devices operated off track. Among the devices to be considered under this classification are
Caterpillar cranes and shovels,
Motor trucks and motor truck cranes for handling material in congested yards,
Paint sprayers,
Post hole diggers.

Track maintenance is rapidly growing beyond the hand labor stage. It is too vital and important to successful operation to be done with anything less than the best and most modern mechanical devices. To illustrate the economical advantages of these mechanical aids, examples of methods and costs of operation of the machines now in use are presented in the following pages. Additional tabulated information is shown in Addenda to this Appendix.

The railroads making reply and the devices referred to are identified by number and letter, respectively. Members wishing to communicate with any road may secure the name from the Chairman of this Committee.

(1) RAIL LAYING MACHINES

Railroad No. 2

At the present time we are using the E crane exclusively for laying 110-lb. rail. We find that with one operator and three men handling rail this machine will lay as much as two track miles per eight-hour day, providing the gang is so organized as to keep up with the other work. However, ordinarily, our gangs are organized to lay only 3500 to 5000 track feet per day and as a consequence the machine is not kept constantly busy. If the laying of 110-lb. rail was done by hand, 24 men on tongs would be required, or a labor expense of $71.04 per day, at an hourly rate of $0.37. The operation of the crane costs only $15.46 per day, making a saving of approximately $55.28 per day. In addition to the economy in laying rail there is a considerable saving in reduction of personal injuries, as handling rail by tongs is very dangerous, usually resulting in a large number of personal injuries. Operated in conjunction with an air compressor, we have found this crane useful in handling bridge work, for driving sheet piles, moving bridge material, handling large stone from masonry thrown out on embankment for use as riprap, handling buckets, making foundation excavation, and handling batch boxes from stock piles to concrete mixer, resulting in a large saving in labor expense and general speeding up of the work. It may also be used to advantage for loading and unloading material in yards, saving work-train expense.

We also use for laying and loading rail, steel cranes operated by gas engines. These machines are equivalent to about 17 men in laying or loading rail, and may be utilized for handling material in shops and yards.

Railroad No. 17

Following is a comparison of the amount of rail laid by hand, and with the P rail layer, for a period of six days of eight hours each:

Using rail tongs, laid 19,717 feet of rail in 1,762 man-hours, averaging 90.03 feet per man per day.

Using rail crane, laid 21,130 feet of rail in 1,856 man-hours, averaging 91.07 feet per man per day.

These figures include full bolting, spiking and applying rail anchors in each operation. Comparative figures on the cost of unloading rail by hand and with machine are not available.

Railroad No. 19

The only device included in your list on which we can furnish data that will be of value is the E rail laying machine:

Cost	$4500.00
Interest and depreciation	16%
Cost per mile of track laid (approximately)	30.00
Expected life of machine—years	10
Power	Gasoline motor
Force required to set rail—number of men	5
Saving over hand labor, laying one track mile	44.28
As this machine is equally useful for picking up and piling old rail, the above result should be increased to $80 per mile, from which should be deducted the operating cost, $30, resulting in a saving per mile of	50.00
On this basis the total saving in laying 16.5 track miles on one district will be	825.00
The added advantage of using this machine both for loading and laying rail on branch lines will result in an annual saving of	1000.00

Other examples of savings resulting from the use of this machine are shown below:

		Per Foot of Rail	*Per Mile of Rail*
(a)	Cost by hand	$ 0.0268	
	Cost with crane	0.0228	
	Saving	0.0040	$42.24
(b)	Cost by hand	0.0180	
	Cost with crane	0.0120	
	Saving	0.0060	63.36
(c)	Cost by hand	0.0351	
	Cost with crane	0.0296	
	Saving	0.0055	58.59

Equal savings may be obtained by using the machine for loading rail, and on this basis we think it would be fair to figure a saving of $100.00 per mile for laying and loading rail. The decreased personal injury hazard is an important feature in its favor. The machine may also be utilized in other work.

Railroad No. 41

Following is comparison of the cost of laying rail by hand and by rail laying machine, including depreciation and interest on investment in equipment and all expense incidental to laying new rail, but excluding expense of picking up old rail:

	Per Ton
Laying rail by hand	$3.36
Laying rail with crane	1.84
Saving	$1.52

Railroad No. 49

We use C maintenance of way steam derricks and locomotive cranes for loading and unloading rail and other material in the Maintenance of Way and Construction Departments. Where it is economical, they are used for relaying rail in main tracks and sidings.

Railroad No. 54

We have used a few such devices, but it is difficult to obtain reliable figures on their operation; however, the enclosed statement (incorporated in tabulated addenda), covering the E rail laying machine, will give an average. To obtain full efficiency in laying rail with this device it is desirable to use a force of 80 to 100 men.

Single-end track derricks of ten tons capacity have been used for many years, one being furnished to each track supervisor.

Railroad No. 56

We have four E rail laying machines, equipped with 25-ft. booms for handling 39-ft. rails. Each machine is operated by one man, paid $0.75 per hour for actual time worked. We consider that this device has fulfilled a long-felt need of those engaged in track laying, as it is a happy medium between a hand-operated machine and the somewhat bulky steam crane. It can be most economically and successfully used in the following work:

(1) Loading and unloading rail, frogs, switches and other material.

(2) Laying track—pioneer, parallel or relay.

(3) Transporting men to and from work, where traffic is not dense.

(1) In loading and unloading material, the machine may be used either directly on the track or mounted on a flat car. For unloading in a storage yard it is preferable to use it direct on the track, but for distributing rail or loading old rail from the right of way may be operated to greater advantage if mounted on a flat car. With flat cars it can be run from one car to another, while with gondolas each car must be switched after being loaded or unloaded.

(2) It is especially adapted for track laying, and was used in laying pioneer track on recent new construction, with the following plan of organization:

(a) Ties were kept ahead with teams.
(b) Rail crane was placed ahead of flat car containing rail.
(c) Three rails were dropped from flat car.
(d) Train was backed.
(e) Machine moved back, picked up the three rails previously dropped, moved forward and heeled these rails into place, then moved back and picked up three more rails, repeating the operation. As each three rails were made safe, the crane had three more ready. Rail from flat cars was thrown off by hand; however, this may be eliminated by using another machine behind the flat car. Two machines were used, working from opposite directions.

The cost per mile to lay pioneer track by this method is shown in the following statement:

Cost of Laying One Mile of Track With E Rail Crane

Operation	*Number of Men*	*Man Hours $0.75*	*Man Hours $0.583*	*Man Hours $0.50*	*Cost*
Placing ties ahead of machine	8	..	..	40	$ 20.00
Applying angle bars to trailing end of rail ahead of machine	4	..	..	20	10.00
Man with machine fastening and releasing rail hooks	1	..	..	5	2.50
Men with rail tongs to guide trailing end of rail to place	2	..	..	10	5.00
Man with track gage ahead of machine	1	..	..	5	2.50
Man with lining bar to throw leading end of rail to gage	1	..	..	5	2.50
Foreman with gang at machine	1	5	..	..	3.75
Machine operator	1	10	..	..	7.50
Total for gang with machine working 5 hours, laying 1 mile	19	15	..	85	53.75
Bolters following machine, applying one bolt to free end of angle bar	2	..	..	20	10.00
Man marking end of ties for location of tie plates	1	..	..	10	5.00
Distributing tie plates, spikes and bolts	6	..	..	60	30.00
Applying tie plates	4	..	..	40	20.00
Spacing ties	6	..	..	60	30.00
Bolters full bolting	13	..	..	105	52.50
Spikers full spiking	92	..	..	860	430.00
Foremen with follow-up gang	2	15	..	..	11.25
Assistant foremen with follow-up gang	2	..	20	..	11.65
Total for follow-up gang	128	15	20	1155	600.40
Total, machine and follow-up gangs	147	30	20	1240	654.15

Note.—Material previously unloaded from adjacent track but not distributed. Unloading cost not included. Rail crane was used 5 hours, machine gang then turned back and assisted in spiking and bolting.

This crane is very efficient for laying parallel track, as if traffic is dense on existing tracks the machine can be operated on the new track.

We have not used it in relay work, but in our opinion it could be utilized to advantage where traffic interruptions are not too frequent. Under all conditions of rail laying operations, the crane is equivalent to a minimum of 13 workmen, exclusive of time saved in carrying out the work.

(3) The machine will attain a speed of ten or fifteen miles an hour and may be used for transporting workmen, but this is not recommended if other transportation is available.

Summarizing, we consider this device ideal in every respect. Other than the economies effected in labor and time, a very desirable feature is the quality of track laying, especially in uniform expansion secured.

(2) RAIL OILING DEVICES (for preventing corrosion)

Railroad No. 2

Type of machine		M Rail Oiler
Oil carrying capacity	Trailer Gal.	1500
	Tanks on oiler "	640
	Total "	2140
Force to operate (operator, conductor-pilot, flagman)		3
Cost (including trailer tank)		$7500.00
Interest, depreciation and repairs, per working day (based on 10 years expected life)		5.30
Cost per track mile, oiling rail and fastenings, including interest, depreciation, repairs and operating expenses		0.85
Cost of oil, per track mile (including transportation)		8.20
Total cost, per track mile		9.05
Estimated cost of performing work by hand—		
20 men @ $0.40 per hour, 8 hours per mile		64.00
Material—per mile		14.00
Total estimated cost per track mile, by hand		78.00

We have no figures on the cost of oiling joints alone, by machine, but it is estimated at $2.50 per track mile, including $0.70 for fixed charges and operating expenses and $1.80 for oil applied. The estimated cost by hand, per track mile is:

Labor	$5.00
Material	3.00
Total	8.00

In oiling rail and fastenings, work train is not required if two cars of oil are used, moving them ahead by local freight train on alternate days.

Railroad No. 41

Five F automatic flange oilers were installed during May, 1927. It is estimated that the use of lubricators has prolonged the life of rail from 25 to 50 per cent. Other benefits obtained are, lower maintenance costs, regaging having been cut at least in half, less train resistance, and, undoubtedly, wheel flange wear has been decreased.

Railroad No. 54

We use the S oil sprayer, which sprays both sides of the rail from the head down, including spikes and tie plates. About 2700 miles of track are covered annually, using what is known as No. 45 road oil. The cost per mile is small and we believe it is justified by the results.

Railroad No. 55

We have an S oil sprayer, built in our shops. It is in service about sixty days a year, and is handled by a locomotive while in operation. The oil is applied under pressure, the pumps being operated by steam from the locomotive. One man operates the sprayer. It would be impractical to do this work by hand and the expense would be prohibitive.

Railroad No. 57

We have an M track oiling machine of the latest type, equipped with trailer tank of 2400 gallons capacity; purchased this year at a cost, including freight and store expense, of $7665.00. During June we oiled, out of face, the base of rail and fastenings on 214 miles of main track, at a cost of $6.10 per track mile. This machine may be used also for spraying oil on the roadbed and for other purposes.

(3) THE ADVANTAGES OF OPERATING IN PAIRS OR IN MULTIPLE UNITS, MACHINES SUCH AS DITCHERS, RAIL LOADERS, BALLAST CLEANERS, ETC.

Ditchers

Railroad No. 28

We use steam ditchers in tandem when it can be done to advantage. Where the work is light or accuracy is essential, only one machine is economical. At present we are operating two ditchers in one train for heavy ditching in cuts, but when the rough work is finished one machine will be used to trim up. We have no detailed figures of the cost of operating two ditchers compared with one alone, but ordinarily the output is doubled, although occasionally there will be lost time should one machine get ahead of the other. Under favorable conditions, we believe it is fair to assume an average increased output of 75 per cent.

Railroad No. 49

The operation of ditchers, rail loaders and C locomotive cranes in tandem is economical and affords practically double service with one work train.

Railroad No. 50

We have used ditchers in tandem with one work-train in picking up rail released on large relaying projects, and although there is some economy in this method of operation it is not possible to secure double the service that would be obtained by having a separate work-train for each machine. However, we have obtained good results in operating locomotive cranes in tandem for unloading bank widening material, but our experience has not been sufficient to enable us to furnish information as to savings effected.

Railroad No. 53

We have obtained good results from the use of ditchers in tandem when working in heavy cuts. In finishing up, working at the end of cuts, etc., full use cannot be made of the second ditcher, but we estimate an average saving of 35 to 40 per cent in work-train expense.

Railroad No. 55

Ditchers are always operated in tandem with one work-train, and rail loaders are similarly used when conditions permit. By this method the output per work-train is about doubled.

Railroad No. 57

We have to some extent used ditchers and rail loaders in tandem, but cost figures are not available. However, considerable saving is effected by this method of operation, particularly in work-train expense.

Rail Loaders

A large eastern railroad has utilized gasoline crawler cranes in units of three, mounted on gondola cars, for distributing and laying new rail and picking up rail released (Fig. 1).

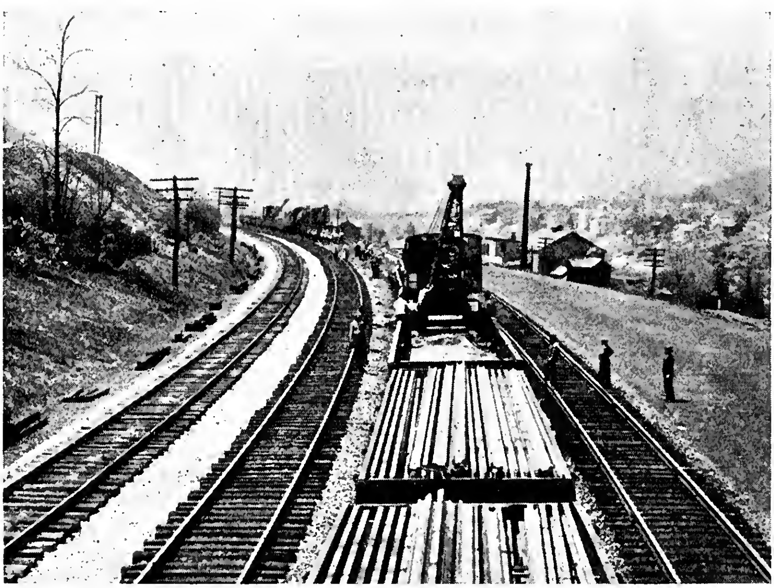


Fig. 1—Pennsylvania Railroad Laying Rail with Three No. 3 Northwest Cranes, Bolivar, Pa.

The first crane is used for distributing, the second for laying, and the third for picking up. Two work-trains are used, one for handling the first crane, the other for the second and third cranes. As the rail is distributed, a gang follows, pulling the outside spikes, unbolting and lining out the old rail; then the second work-train proceeds with the laying and pick-up cranes, followed by the spiking crew.

A record of one operation shows 322 130-lb. 39-ft. rails were laid, spiked, bolted, bonded and the old rail picked up, in 101 minutes, at a cost of $2.62 per ton. Comparative cost figures are not available, but it is evident that considerable saving could be effected as compared with other methods.

This plan should be especially adaptable to double or multiple track lines as it permits taking a section of track out of service only once for the complete relaying operation, thereby affording minimum traffic interference.

Railroad No. 2

In unloading rail considerable economy can be effected by using two rail-laying machines mounted on flat cars, in one work-train. Rail can be unloaded on both sides of the track with the train moving about two and one-half miles per hour, thus eliminating stops except for road crossings and other obstructions. This plan may be followed also in picking up rail. The principal advantages are, increased output, reduced personal injury hazard, and the saving of about 75 per cent of the expense of a second work-train.

Ballast Cleaners

A large eastern railroad reports the following:

Locomotive cranes have power equaling from 100 to 250 men. Maximum efficiency is obtained when used on work where they replace manual labor in large numbers. One class of track maintenance in which considerable economy may be effected by their use is in cleaning stone ballast. The saving which has been effected by working these cranes and screens in units of four, as compared with its operation of a single crane and screen, and cost of doing the work by hand, is shown in the following statement:

Cost of four cranes and screens	$56,000.00
Annual cleaning, 44 miles of double track, in 112 working days, at $473.00 per mile	20,812.00
Cost to clean with hand forks and hand screens	93,720.00
Saving	$72,908.00
Less interest and depreciation	6,500.00
Net saving, per annum	$66,408.00
Return on investment	118%
Cost of one crane and screen	$14,000.00
Annual cleaning, 11 miles of double track, in 112 working days, at $1,110.00 per mile	12,210.00
Cost to clean by hand, at $2,130.00 per mile	23,430.00
Saving	$11,220.00
Less interest and depreciation	1,620.00
Net saving, per annum	$ 9,600.00
Return on investment	40%

The saving by the use of a single crane and screen is considerable, but is limited by failure to assign the more economical number of machines and thus obtain the maximum in service and efficiency from the mechanical equipment and releasing labor for other track work.

An eastern road using locomotive cranes with vibrator screens furnishes the following information:

Output per crane for an eight-hour period:

Actual time worked	5 hr. 12 min.
Track covered, lin. ft	1730
Ballast cleaned, cu. yd	308

Daily operating cost, 4 cranes working as a unit:

Work train expense	$ 80.00
Maintenance of way labor	89.00
Fuel and supplies for cranes	20.00
Total	$189.00
Cost per lin. ft. of center ditch	0.027
Cost per cu. yd. of ballast	0.150

Applying these figures to the plan of another eastern line, which is very thorough, as it includes the ballast shoulders, gives the following cost data for cleaning a double track line with cranes and screens operated in units of four as compared with a single crane and screen:

	One Crane	*Four Cranes*
Expense of trains:		
Cranemen and firemen	$ 11.00	$ 44.00
Laborers	10.00	40.00
Foreman	5.00	5.00
Fuel and supplies	5.00	20.00
Work-train expense	80.00	80.00
Total	$ 111.00	$ 189.00
Cost per mile of double track:		
Cubic yards of ballast	3,316	3,316
Time required—days	10	2.5
Cost	$ 1,110.00	$473.00
Saving by use of four cranes		$637.00
Comparative economy in multiple operation:		
First cost of cranes and screens	$13,000.00	$52,000.00
Additional first cost		39,000.00
Annual savings in operation, based on cleaning 33 track miles		22,120.00
Interest and depreciation		6,500.00
Net saving, per annum		$15,620.00
Return on investment		40%

Advantages and Economy of Vibrator Screens

(a) At least 10 per cent more dirt is removed from the ballast than with still screens.

(b) They permit screening ballast which would be too wet for handling with still screens.

(c) Suspension of work-train cleaning operations is avoided, with consequent expense due to idle trains or outfits screening ballast and not thoroughly cleaning it, amounting to a time saving shown by actual operation to be approximately 15 per cent.

First cost of vibrator screen	$2,600.00
Interest and depreciation:	
Per annum	676.00
Per day (84 days per working season)	8.00
Additional cost per cubic yard (at 308 cu. yd. per day)	0.026
Cost of screening with vibrator screens, per cubic yard	0.60
Saving effected by vibrator screens	15%
Cost with still screens, per cubic yard (60 + 85 per cent)	0.70
Saving with vibrator screens, per cubic yard	0.10
Net saving per cubic yard	0.074
Net saving per day (308 cu. yd.)	22.80
Net saving per season (84 days)	1,915.00

With the present design of vibrator screen, dirt from the ballast is disposed of into a car. The cost of unloading the dirt is estimated to be $0.02 per cubic yard of ballast cleaned. A saving might be effected by depositing some of this dirt directly on the adjoining banks without rehandling. This would not be possible on more than half the mileage, due to cuts and fills, adjacent tracks, station buildings and other obstructions. Assuming that half must necessarily be handled on cars, the added cost to dispose of dirt by this method would be $0.01 per cubic yard of ballast cleaned, leaving the following net saving:

Saving per cubic yard	$ 0.074
Less cost of handling dirt, per cubic yard of ballast	0.01
Net saving per cubic yard of ballast cleaned	0.064
Net saving per day (at 308 cubic yards)	19.70
Net saving per season (84 days)	1,655.00

The adoption of vibrator screens is justified, (1) because a more thorough cleaning is obtained, (2) they may be operated under relatively damp weather conditions when still screens could not be used, (3) at an added cost for vibrator screens of $0.026 per cubic yard of ballast cleaned there is a net saving of $0.074 per cubic yard when compared with the use of still screens.

Moreover, under average conditions, where locomotive cranes and screens are utilized for cleaning ballast, maximum efficiency is obtained by multiple operation, preferably in units of four. However, this is not always practicable, owing to traffic density or other local conditions, and in some instances they may be used to better advantage either singly or in pairs.

The following figures show one day's performance of locomotive cranes and ballast screens used in tandem, without work-train but with train crew, based on actual screening time of 3 hours 52 minutes within eight hours:

Total expense, per day	$74.32
Cubic yards of ballast cleaned	305
Cost per cubic yard	0.24

Another large eastern road uses caterpillar cranes, equipped with clamshell buckets, and mounted on gondola cars (Fig. 2). The cranes are of special design, with narrow treads, so that they may be run through drop-end cars. The cabs are tapered to permit operation on a multiple track line, with the boom swung to a maximum angle of 15 degrees from center of track, being provided with a removable automatic stop which limits rotation to this angle. Two methods of operation are pursued:

(1) The foul ballast is loaded in dump-bottom gondola cars and taken to a central cleaning plant for washing and rotary screening.

(2) The ballast is cleaned by a stationary screen mounted on a gondola car adjacent to the crane. When car is filled, the crane moves the screen to the car in which the crane was previously located.

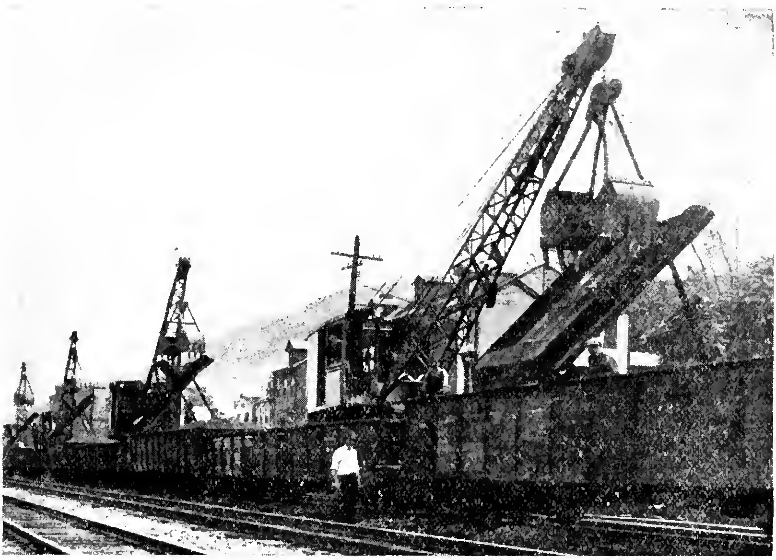


Fig. 2

Satisfactory results are obtained under both plans, and although cost figures are not available it is estimated that the work is performed at about one-third of the expense of screening by hand.

Railroad No. 41

Steam ditchers, equipped with clamshell buckets, and inclined screens mounted on gondola cars, are worked in units of three to five. A foreman has charge of one unit, with an engineer and fireman on each machine; laborers are employed as required. This plan is best adapted to multiple track lines where uninterrupted use of one track may be had for long periods. The amount of work performed depends upon the traffic density on the adjacent track, as insufficient clearance necessitates the suspension of cleaning operations during the passing of trains. However, the economy effected by this method is considered sufficient to justify its continuation. The amount of track cleaned while working is governed by the slowest operator. Performance under "best" and "average" conditions is shown in the following statement:

	Best Conditions			Average Conditions	
Machines in Unit	*Time Worked*	*Lin. Ft. Track Cleaned*	*Lin. Ft. per Hour per Machine*	*Time Worked*	*Lin. Ft. per Hour per Machine*
6	2'10"	2860	220	1'45"	158
5	5'20"	5610	215	2'45"	188
4	5'	5013	251	3'10"	224
3	5'20"	3993	249	3'20"	239
3	3'	2835	315		

Gasoline ditchers, equipped with clamshell buckets, have been used, at a saving in cost compared with steam ditchers, but detailed information is not available.

Where traffic density permits continued operation for periods of long duration, satisfactory results are obtained with C cranes in tandem and in units of three to five. In 25 working days, or 97 unit days, cleaned 52,800 feet of inter-track space, at a cost of $0.072 per foot.

Inter-Track Ballast Cleaning Devices

Railroad No. 41

On heavy traffic double-track lines, ballast cleaning machines operated on track are not economical, and inter-track devices may be used to advantage.

In one operation of the R inter-track ballast cleaner, 150 lin. ft. of track was covered per hour of actual working time; maximum average per eight-hour day, 747 lin. ft. Working in wet clay-fouled ballast, averaged 483 lin. ft. in eight hours; maximum 1131 lin. ft. The cost of cleaning inter-track space averaged $0.07 per lin. ft., compared with $0.09 using steam ditchers. The force required for one machine consists of a foreman, operator-mechanic, and six or seven laborers. First cost, approximately $10,000.00.

This device may be operated in tandem or in multiple, with one foreman in charge of each unit, but this has not proved practical or economical, as the machines are usually a mile apart, and when worked in batteries are so widely separated that efficient supervision by one foreman is impossible.

Railroad No. 54

We have 18 R ballast cleaners, which have been in use only a short time and detailed information as to economy effected is not available, but we believe they are justified by the results.

(4) DEVICES OPERATED OFF TRACK

Caterpillar Cranes and Shovels

Very satisfactory results were obtained on a western railroad in operating a gravel pit with a steam shovel mounted on caterpillar tractors. The material excavated was a mixture of gravel and coarse sand. Self-clearing ballast cars of 45 cubic yards capacity were used for loading. Due to steep grades in the pit operation, a locomotive was kept in constant attendance to handle cars. The shovel crew consisted of an operator and fireman, with a team and driver to haul coal and water.

For a period of twenty-one days, during which the shovel was idle eight days on account of car shortage, and one Sunday when not working, the output for twelve working days averaged 16 cars, or 720 cubic yards, ranging from a maximum of 22 cars, 990 cubic yards, to a minimum of 14 cars, 630 cubic yards. Water, fuel and lubricants, on days worked, averaged:

Water	2100 gal.
Coal	1500 lb.
Valve oil	1 qt.
Engine oil	.5 gal.
Cup grease	3 lb.

In a gravel pit operation on another railroad, a gasoline shovel, mounted on caterpillar tractors, is utilized for excavating material and loading it on cars (Fig. 3). The empty cars are placed at the pit in the morning by one train and pulled at night by another, thus eliminating a locomotive and work-train at the pit. Only one man is employed to operate the shovel, a foreman and night watchman not being required. Considerable economy may be effected where this method is practicable.

In constructing a three-span steel and concrete bridge, a gasoline caterpillar shovel-crane was used in excavating for piers and driving 30 ft. wooden foundation piling, there being 66 piles under each end pier and 94 under each intermediate pier. Power for the steam hammer driving the piling was furnished by an auxiliary boiler. The crane acted as a support for the hammer leads. Although unusual difficulties were encountered, the operation was considered a success.

A gasoline caterpillar one-yard shovel, loading cars, handled 2220 cubic yards of material in 26 working hours, an average of 85.3 cubic yards per hour. In overcasting, this machine handled 5080 cubic yards of material in 48 working hours, averaging 105.8 cubic yards per hour.

Caterpillar shovels are well adapted for grading new roadbed, as they can be handled and moved over rough ground with an ease and speed that would be impossible with a track-mounted shovel, and the expense of shifting track is eliminated entirely.

When mounted on a flat car, this type of shovel may be used for ditching in cuts. If provided with 18 ft. 6 in. dipper sticks and mounted on a flat car having a deck height of 4 ft. above top of rail, it can dig to a depth of 7 ft. 6 in. below deck of car; with 20 ft. dipper sticks a depth of 9 ft. can be reached. To facilitate travel of the machine when mounted on cars, rails should be spiked between the treads.

For digging trenches, a pull-shovel attachment is obtainable. This may be used also in wide cuts to excavate for laying tile drains.

Fig. 3

Railroad No. 2

A steam shovel mounted on caterpillar tractors is operated in a gravel pit. Formerly, when this shovel was mounted on track, eight men were required, while at present only four are used, effecting a reduction of $11.84 per day in labor expense. These men clean the machine, pole the material to within reach of the shovel, and perform other work incidental to the operation. The shovel output is increased, as no time is lost in laying track for moving the machine. However, an objectionable feature with the caterpillar mounting is that when shop repairs are necessary the shovel must be transferred to car trucks for handling in trains. This requires the services of a derrick, machinists and the shovel crew, and is quite expensive.

We also have one H gas-air and one H steam caterpillar shovel. These machines are used as cranes, shovels or draglines, either off or on cars, the best results being obtained on jobs involving less than 30,000 cubic yards of material. They may be used for digging and cleaning out ditches for about half the cost with teams. The gas-air machine is the cheaper to operate, as there is no expense for handling coal and water, and a foreman and watchman are not required.

Railroad No. 50

The AA combination crane and ditcher, when used off track, is equivalent to a small steam shovel and more economical to operate, as a work-train is not required and there is greater latitude in excavating operations.

Satisfactory results were obtained with an AB one-yard shovel operated off track as a drag line. The ballast shoulder is not disturbed and drainage ditches can be excavated in obtaining material for restoring banks. However, its use is restricted by the height of roadbed embankment.

Railroad No. 55

We have one steam and nine gasoline caterpillar shovel-cranes, varying in first cost from $12,000.00 to $14,000.00, the oldest machine having been in service about six years. Each machine is manned by an operator and helper. These machines are equipped with a one-yard dragline bucket and a ⅞-yard shovel bucket, and are used in all classes of excavation where draglines or small shovels can be operated to advantage; as cranes for handling material; and for pile driving, by attaching leads to the booms. Cost figures are not available, but it is felt that the economy effected earns a good return on the investment.

Caterpillar Draglines

Another off-track device, for which a variety of uses may be found in railway track maintenance, is the caterpillar dragline (Fig. 4). It is economical in operation and permits carrying out work which would be prohibitive in cost and impractical to perform with hand labor. It is especially adapted for trenching and cleaning out ditches and may be utilized to advantage in bank widening. It will move over very rough ground with comparative ease and speed and can be operated even in water. By attaching leads to the boom it may be utilized for pile driving, with either a drop or a steam hammer. Some of the uses made of this machine by various railroads are summarized in the following paragraphs:

A gasoline dragline, equipped with a 40-ft. crane boom, was used for widening shoulders on a double-track line in a sagebrush desert country. The material was excavated on the right-of-way and placed along the outside of the ballast line without disturbing or fouling the stone ballast, 600 to 700 cubic yards of material being handled daily. The material was difficult to excavate, varying from a surface of loose dry sand to a sub-soil of almost the hardness of rock, at a depth of five or six feet.

On another railroad, in widening embankments, from 900 to 1300 lin. ft. of embankment was widened daily, on one side, the average height of fill being 12 feet. Where the material was easily handled, 160 cubic yards were moved per hour.

In another operation, digging drainage ditches, 9987 cubic yards of material were removed in eleven working days, at a cost of $0.048 per cubic yard, including labor, supplies and equipment rental of $16.70 per day.

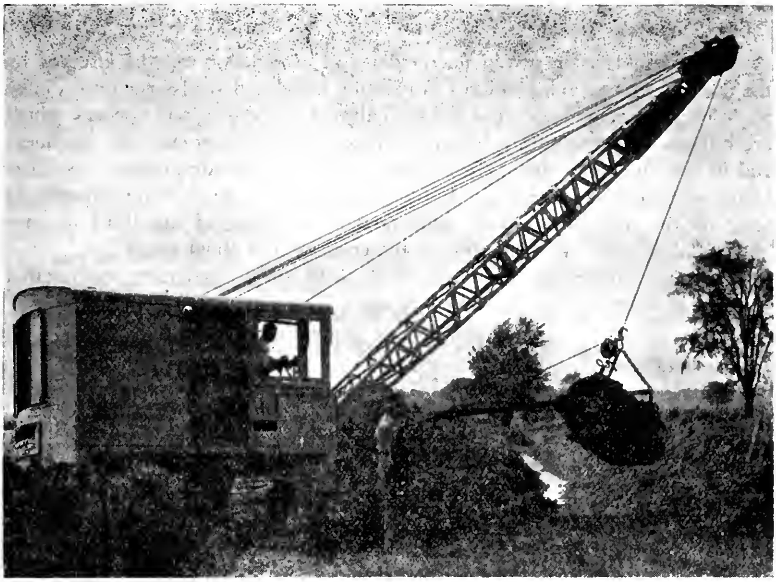


Fig. 4

Points to Look For in Considering Caterpillar Cranes and Shovels

1. Large bore, long stroke, slow-speed motor—for maximum power.
2. Large crawler dimensions—for stability.
3. Positive traction on both crawlers at all times—maximum power.
4. Ball-bearing mountings for high-speed shaft—maximum power, minimum wear.
5. Smooth jointed treads, self-clearing, self-adjusting to uneven ground —ease in crossing tracks.
6. Minimum moving parts—simplicity, long life.
7. Internal teeth in ring gear—freedom from dirt.
8. Annealed steel castings for traveling and rotating bases, assuring perfect shaft and gear alinement.
9. Chain and sprocket drive to crawlers—absorb shocks—minimum breakage.
10. Large sheaves—save cable.
11. Alloy heat-treated steel—for maximum strength and wear.
12. Over-all dimensions to clear bridges and tunnels.
13. Easily operated controls.
14. Ease in conversion from shovel to crane, dragline or pull-shovel.
15. Two drums on a single shaft—simplicity and ease of control.
16. High underframe clearance.
17. Cut steel gearing—long service and smooth, silent operation.
18. Cable crowd—saves power, eliminates rack and pinion.

Many other points should be given consideration, but the foregoing are of major importance.

Paint Spraying Devices

Considerable economy in maintenance of way labor may be effected by the use of paint spraying devices in painting wood and steel structures. They are especially adapted to steel bridge painting, as angles and corners which are difficult to reach with a brush can be covered with greater thoroughness and in less time, paint is applied more evenly, and the air pressure produces better adhesion. Painting can be done by machine in about one-fourth to one-half the time required by hand, and at a saving of one-third to one-half in labor cost. The quantity of material used is about equal.

Savings effected by railroads using paint spray equipment are recited in the following:

Painting Steel Bridges

Bridge "A" *Actual Cost with Paint Sprayer*

Cleaning bridge metal by hand	$325.00
Spot painting with red lead	40.00
Applying bridge paint	90.00
Total	$455.00

Estimated Cost by Hand

Cleaning bridge metal	$325.00
Spot painting with red lead	75.00
Applying bridge paint	180.00
Total	$580.00
Saving	$125.00

Bridge "B" *Actual Cost, with Paint Sprayer and Pneumatic Cleaning Tools*

Cleaning bridge metal	$ 75.00
Spot painting with red lead	10.00
Applying bridge paint	40.00
Total	$125.00

Estimated Cost by Hand

Cleaning bridge metal	$150.00
Applying red lead and paint	90.00
Total	$240.00
Saving	$115.00

Cost of Applying Paint, per Square Foot of Surface with Sprayer

Applying paint	0.0025
Starting machine, moving scaffolding, etc.	0.0025
Total	0.0050

By Hand

Total labor cost applying paint	0.01

A paint sprayer, operated by two men, was used in painting a large steel bridge, consisting of truss spans with numerous small corners which are difficult to clean and paint by hand, particularly in the bottom chords and floor system. Eight men employed in cleaning the metal had difficulty keeping ahead of the paint gun. Pneumatic chipping hammers, steel wire brushes, and jets for blowing scale out of the corners, were provided. The entire job was completed in about one-fourth of the time ordinarily consumed by hand. Pneumatic cleaning tools aided materially in speeding up the work, and their use should be considered in steel bridge painting.

Another road reports that the use of paint sprayers has reduced their painting cost from an average of $0.015 to $0.005 per square foot.

A time study conducted, with two men operating a paint sprayer and two skilled painters working by hand, developed the following interesting comparison: Working on large surfaces, 4000 sq. ft. were covered in five hours with the sprayer, while only 1000 sq. ft. were painted by hand. Two men were assigned to the sprayer to facilitate handling of the hose and scaffolding.

Paint sprayers are equally efficient for painting buildings and structures, although the output is retarded by openings and trimming.

Railroad No. 17

The following statement is indicative of the economy that may be effected with paint sprayers, compared with the cost by hand:

STEEL BRIDGE PAINTING

Estimated Cost to Paint by Hand

Paint	$752.00	
Brushes	38.00	
Total cost of material		$ 790.00
Labor cleaning and painting		675.00
Total cost		1,465.00

Actual Cost of Oiling Bridge, with Sprayer

Crude oil		$ 11.34
Applying oil	$ 86.80	
Cleaning metal	210.13	
Total labor cost		296.93
Total cost		$ 308.27
Saving in labor expense		$ 358.07

Painting Shop Fence—Applying One Coat

	By Hand	*With Sprayer*
Time worked	1 Hr.	1 Hr.
Square feet of surface covered	500	2000
Gallons of paint used	4	12
Cost of paint	$4.40	$13.20
Cost of application	.65	.65
Total cost	5.05	13.85
Average cost per 100 sq. ft.	1.01	0.69

Railroad No. 50

Using a B paint sprayer, driven by a 3½ h.p. gasoline engine, and operated by two men, in painting large surfaces, a 45 per cent reduction has been effected compared with the cost of hand painting.

Railroad No. 52

Our bridge and building gangs have used paint sprayers for about 15 years with satisfactory results.

Railroad No. 53

This device is productive of economy, but its effectiveness may be destroyed by use on small structures at isolated locations.

Railroad No. 57

We use two V paint sprayers on frame and steel structures. The average cost of painting wooden structures is $0.03 per sq. ft. by machine, compared with $0.04 by hand; and for steel bridges $3.50 per ton of metal, by machine, compared with $4.00 by hand.

GENERAL OBSERVATIONS

This report presents a synopsis of the practices, opinions and conclusions of railway maintenance engineers in the United States and Canada, and from them the following observations are made:

(1) To effect maximum economy, machines must be kept at work.

(2) To accomplish this, local supervisory officers responsible for their operation must be impressed with the fact that interest on the investment accumulates continuously.

(3) Adequate maintenance is important. Maintenance of Way Department shops, manned by experienced mechanics, are recommended where the amount and character of work justifies.

(4) To obtain maximum efficiency with labor-saving appliances, the employment and training of foremen and operators is becoming increasingly important. These men must possess mechanical sense and be free from prejudice against such devices.

(5) Each operation should be studied to determine the number and type of machines required to obtain the best results. This requires the co-ordination of thought and effort of management and the men in the field.

(6) Avoid mechanical saturation.

Conclusions

During the past four years, your Committee has assembled information covering some sixty labor-saving machines and devices in general use at the present time. From this information the following conclusions are drawn:

(1) That labor-saving machines and devices carefully selected, efficiently manned, properly supervised and maintained, are productive of sub-

stantial economies in maintenance of way operations, and their use is recommended.

(2) Their economy is determined by comparison of the costs of the labor-saving operation with other methods or practices. It should be emphasized that savings effected on one railroad cannot consistently be compared with results on another road, or even upon one division, because of the many variables, such as traffic density, methods of operation, and other conditions which must be considered.

Recommendation

The Committee recommends that this report be received as information and the subject closed, and that further effort should be directed toward the study of other phases of the problem of effecting economies in the use of maintenance of way labor.

Rail Laying Machines

R R	Machine	First Cost	Depreciation	Operating Expense	Maintenance Expense	Avg. Life, Yrs.	Power	Max. Load Capy., Lbs.	Force to Operate	Cost per Unit with Machine	Cost per Unit by Hand	Force, by Hand	Days Used per Year	Speed per Hour	Work Train	Other Uses	Advantages	Disadvantages
5	E	$4467.00	......	....	....	....	Gas	3,000	4 men	$ 0.083 lin. ft.	$ 0.118 lin. ft.	7 men	275	12 miles	No	Handling material	....	....
17	E	6300.00	$315.00	$144.00	$191.00	20	Gas	3,000	....	0.037 lin. ft.	0.065 lin. ft.	16 men	109	15 miles	No	Derrick	Economical and reduces personal injury hazard	
25	E	4915.00	325.00	2100.00	20.00	15	Gas	3 tons	4 men	0.09 per 39 ft. rail	0.20	26 men	192	75-90 rails	No	....	Economical and reduces personal injury hazard	Traffic interruptions decrease output
54	E	4500.00	180.00	1800.00 per year	50.00 per year	25	Gas	2.5 tons	5 men	17.00 per mile	31.00 per mile	16 men	225	65 rails	No	Handling material	Saves hand labor	....
....	N	4400.00	400.00 per year	0.60 per hour for operator	1.25 per day	15	Gas, Elec.	4,000	3 men	0.08 per 130 lb. rail	0.60 per 130 lb. rail	26 men	160	20 miles	No	Welding, B. & B. work, reclamation, loading and unloading, transporting men and material	Flexibility	....
13	N	4631.00	......	2169.90	231.55	20	Gas, Elec.	....	4 men	2805.18 per year	6480.00 per year	18 men	90	....	.....	....	Saves $3674.82 per year	....
3	P	425.00	42.50 per year	......	50.00 per year	10	Hand	1 ton	5 men	0.045 per rail	0.16 per rail	16 men	30	60-80 rails	No	None	Faster and saves 11 men	Must be moved from track each closure
13	P	435.79	......	1080.00	21.79 per year	20	Hand	....	3 men	1136.45	5760.00	16 men	90	....	No	....	Net saving $4620.00 per year	....

RAIL LAYING MACHINES—Continued

RR	Machine	First Cost	Depreciation	Operating Expense	Maintenance Expense	Avg. Life, Yrs.	Power	Max. Load Capy., Lbs.	Force to Operate	Cost per Unit with Machine	Cost per Unit by Hand	Force, by Hand	Days Used per Year	Speed per Hour	Work Train	Other Uses	Advantages	Disadvantages
17	P	$ 440.00	$ 44 00	....	....	10	Hand	1,200	....	$ 0.057 lin. ft.	$ 0.065 lin. ft.	16 men	30	....	No	....	Economical. Reduces personal injury hazard	....
25	P	442.00	22.00	$600.00	$ 10.00	20	Hand	6 tons	3 men	0.04 per 33 ft. rail	0.16 per 33 ft. rail	16 men	50	Same as hand	No	None.	Saves labor. Reduces injury hazard	Traffic interruptions decrease output
29	P	300.00	....	7 68 per day	30 00	10	Hand	1,800	3 men	0.96 per hour	5.12 per hour	16 men	100	....	No	None.	Best suited for single track lines where traffic density prevents economical use of power layers or cranes	....
59	P	455 37	45 00	416.00 per month	5 00 per day	10	Hand	2,000	4 men	30.00 per mile	120.00 per mile	16 men	200	....	No	None.	Reduces injury hazard	Difficult to set off on narrow roadbed
43	U	3800.00	20.00 per day	20 00 per day	70 00 per year	15	Gas	4,000	4 men	35.00 per track mile	64.00 per track mile	16 men	100	....	No	....	Speeds up work	....
36	U	5292 45	819.85 per month	356 04 per month	72 66 per month	.....	Gas	3,000	4 men	0 8409 per 100 track feet	3.1437 per 100 track feet	24 men	150	....	......	Ditcher or derrick	Injury hazard much reduced	Must be side-tracked for trains where insufficient clearance prevents using lateral trucks to clear track
3	Loc. Crane	13000.00	2.00 per day	12.00 per day	12 00 per day	15-20	Steam	25 tons	2 men	0.09 per rail	0.16 per rail	16 men	......	60-80 rails	Yes	....	Sets rail in faster	....

Rail Loading and Unloading Machines

RR	Machine	First Cost	Depreciation	Operating Expense	Maintenance Expense	Avg. Life, Yrs.	Power	Max. Load Capy., Lbs.	Force to Operate	Cost per Unit with Machine	Cost per Unit by Hand	Force, by Hand	Days Used per Year	Work Train	Other Uses	Advantages
5	Derrick (Unloading rail)	....	....	....	....	......	Steam	4,000	6 men	$ 0.0024	$ 0.11	16 men	150	......	Load and unload material	....
13	Loader	$1903.00	....	$1621.00	$190.30	15	....	....	5 men	1993.89	5600.00	20 men	70	......	....	Net saving $3601.16
17	Loader	2000.00	$100.00	596.00	85.00	20	Air	2,000	....	0.004 lin. ft.	0.008 lin. ft.	16 men	36	Yes	Derrick	Economical. Decreases injury hazard
17	Splitboom Derrick	6100.00	305.00	....	283.00 per Mo.	20	Gas	3,000	....	....	0.008 lin. ft.	16 men	......	Yes	Derrick	Economical. Decreases injury hazard
17	Rebuilt "AA" ditcher (Rail loader)	3080.00	308.00	....	61.00 per Mo.	10	Steam	2,000	....	....	0.008 lin. ft.	16 men	......	Yes	Derrick	Economical. Decreases injury hazard
51	Ditcher "D" Rail loader	5558.00	556.00	275.00 per Mo.	45.00 per Mo.	10	Steam	1 ton	1 man	....	....	35 men	300	......	None	Saves labor

RAIL OILING DEVICES (FOR PREVENTING CORROSION)

RR	Machine	First Cost	Depreciation	Operating Expense	Maintenance Expense	Avg. Life, Yrs.	Power	Max. Load Capy.	Force to Operate	Cost per Mile with Machine	Cost per Mile by Hand	Force, by Hand	Days Used per Year	Speed M.P.H.	Work Train	Other Uses	Advantages	Disadvantages
58	L	$2800.00	$ 1.00 per day	$17.25 per day	....	25	Gas	....	4 men	$14.00	....	Impractical by hand	30	8	No	None	Rapid and economical method of arresting corrosion	None
17	M	5650.00	565.00 per year	96.00 per year	$120.00 per year	10	Gas	17,500 lbs.	....	1.99	$5.30	25 men	65	10	No	Oil and paint bridges, cattle guards and switches	....	None
33	M	6376.00	638.00 per year	22.00 per day	1.00 per day	10	Gas	2,100 gal. oil	3 men	2.50 joints 10.00 to 13.00 rail and fangs	15.00 joints. Impractical to oil rail by hand	4 men oiling joints	150	3 on joints, 5 on rail	No	Oil road crossings and spray paint and white-wash on bridges, fences and cattle guards	More economical and efficient than hand labor	Machine must be turned on wye
54	S	4350.00	144.00	4031 per year	500.00 per year	30	......	....	2 men	7.60	....	....	30	20	Yes	None	Prolongs life of rail and fastenings	....
17	*	2850.00	142.50	2895	201.00	20	Gas	6,800 lbs.	....	6.96	....	....	40	10	No	None	Economical	None
25	*	3000.00	200.00	5813†	50.00	15	......	....	2 men	11.40‡	Impractical to oil by hand	....	20	6	Yes	None	The only economical method	None

*Machine of own assembly.
†Includes $3875.00 for oil.
‡Includes $8.31 per mile for oil.

MACHINES OPERATED IN TANDEM OR IN MULTIPLE UNITS

RR	Machine	No. in Unit	First Cost	Depreciation	Operating Expense	Maintenance Expense	Avg. Life, Yrs.	Power	Max. Load Capy.	Force to Operate	Cost per Unit with Machine	Cost per Unit by Hand	Force, by Hand	Days Used per Year	Speed	Work Train	Other Uses	Advantages	Disadvantages	Advantages of Tandem or Multiple Operation
Ditchers																				
32	AA	2	$13,000	....	$1500.00	$ 57.00	20	Steam	¾ cu.yd.	2 men	$ 0.25 per cu. yd.	$ 0.50 per cu. yd.	75 men	300	....	Yes	Handling material	Injury hazard reduced	....	Work train expense cut in half
32	AA	2	12,000	....	2300.00	90.00	20	Steam	¾ cu.yd.	2 men	0.20 per cu. yd.	0.50 per cu. yd.	75 men	280	....	Yes	Handling material	Injury hazard reduced	....	....
36	AA	2	5,055	$18.00 per Mo.	2136.97 per Mo.	34.18 per Mo.	....	Steam	......	5 men	0.35 per cu. yd.	0.95 per cu. yd.	93 men	365	....	Yes	Clamshell and steam shovel	Injury hazard reduced	Traffic interruption; delays for repairs to machines	Efficiency doubled at 28 5% increase in cost
52	AA	3	9,000	....	2.00 per hour	550.00 per year	....	Steam	......	6 men	....	....	....	200	....	Yes	General excavation	Injury hazard reduced	....	50% increase output at saving in work train expense
Locomotive Ditchers																				
43	AA	2	32,800	4%	60.00 per day	400.00 per year	25	Steam	......	11 men	0.21 per cu. yd.	0.83 per cu. yd.	56 men	200	....	No	Piledriving	Economical. Injury hazard reduced. Self-propelled: no work train required	....	Output increased 75%
Rail Loaders																				
32	E and U Crane	2	5,300	....	625.00	10.00	20	Gas	5,000 lbs.	20 men	75.00 per track mile	170.00 per track mile	50 men	200	....	Yes	....	More rail picked up with smaller gang	....	50% reduction in work train expense
36	Loaders	2	740	2.78 per Mo.	622.70 per Mo.	8.33 per Mo.	....	Air	2,000 lbs.	9 men	0.268 per 85 lb. 33 foot rail	0.30 per 85 lb. 33 foot rail	23 men	45	Pick up one mile rail a day	Yes	None	Reduced cost and added safety	Progress of work slower	Doubles output at 30% increase in expense
Ballast Cleaners																				
4	R	2	10,000	1000.00 per year	1940.00 per year	435.00 per year	10	Gas	......	7 men	0.83 per cu. yd.	1.25 per cu. yd.	30 men	200	13 c.y. per hour	No	None	Economical	....	Saves salary of one foreman

Labor-Saving Devices Operated Off Track

RR	Machine	First Cost	Depreciation	Operating Expense	Maintenance Expense	Avg. Life, Yrs.	Power	Max. Load Capy., Cu. Yd.	Force to Operate	Cost per Cubic Yard with Machine	Cost per Cubic Yard by Hand	Force, by Hand	Days Used per Year	Other Uses	Advantages
Caterpillar Shovels, Cranes and Draglines															
32	Shovel J	$17,500	....	$1400.00	$ 52 00	20	Gas	1	2 men	$0.11	$0.50	75 men	300	....	....
33	Shovel	9,577	8⅓%	14.00	1.00	12	Gas	0.75	2 men	0.10	0.72	60 men	275	Handling material, grading, ditching, steel erection and general excavation	Can be used where teams and men cannot work
43	Shovel J	20,000	6%	16.00	320.00	15	Diesel	....	2 men	0.07 (Without spotting crew)	0.12 (With spotting crew)	150 men	......	....	....
32	Shovel	15,000	....	050.00	156.00	20	Steam	1.75	5 men	0.10	0.50	75 men	00	....	....
51	Dragline with shovel and crane	12,185	20%	625.00 per Mo.	125.00 per Mo.	5	Gas	1	2 men	0.085	1.00	100 men	300	With shovel can be used in gravel pit	Used for cleaning out cuts and restoring roadbed
51	Dragline with shovel	15,385	20%	750.00 per Mo.	175.00 per Mo.	5	Gas	1.25	2 men	0.07	1.00	150 men	300	Operating gravel pit	....
51	Dragline without shovel	10,614	20%	625.00 per Mo.	125.00 per Mo.	5	Gas	1	2 men	.85	1.00	100 men	300	Use for gravel pit operation with shovel attachment	Used for cleaning out cuts and restoring roadbed
33	Dragline T	9,669	8⅓%	14.00	1.00	12	Gas	0.75	2 men	0.10	0.72	60 men	275	Handling coal and sand,)ank widening, ditching, steel erection, general excavation	Can be used where teams and men cannot work
Motor Truck Cranes															
39	Motor	8,500	8%	16.00 per day	250.00 per Mo.	12	Gas	5 ton	2 men	....	....	....	300	General material handling	Economical

LABOR-SAVING DEVICES OPERATED OFF TRACK

R	Machine	First Cost	Depreciation	Operating Expense	Maintenance Expense	Avg. Life, Yrs.	Power	Force to Operate	Cost per Unit with Machine	Cost per Unit by Hand	Force, by Hand	Speed	Days Used per Year	Other Uses	Advantages	Disadvantages
Paint Spraying Machines																
25	B	$ 754.00	$ 50.00	$ 20.00	$ 5.00	15	Gas-Air	3 men	$ 0.69 per square	$ 1.86 per square	6 men	....	20	....	Increased production at less cost	Unsuitable for trimming. Operator has difficulty breathing on inside work
33	G	572.00	10%	16.00 per day	0.10 per day	10	Air	3 men	0.08 per square	0.14 per square	7 men	50 square yards per hour	200-300	Will operate small cleaning tools	Especially adapted to steel bridge work	Uses 10 to 15% more paint in windy weather
33	V	395.00	10%	16.00 per day	0.10 per day	10	Air	3 men	0.10 per square	0.14 per square	6 men	40 square yards per hour	200-300	....	Paints steel bridges more efficiently than by hand	Capacity only 1 quart, necessitating frequent refilling
3	Spray, scale-hammer and rotary brush	1340.00	134.00	150.00	125.00	10	Gas-Air	9 men*	0.005 per square foot	0.01 to 0.015 per square foot	16 men	....	100-150	Furnishes power for cleaning tools	More efficient than hand painting on steel bridges	....
13	Sprayer	677.00	....	2730.00	33.85	10	......	3 men	2855.89 per year	7668.00 per year	9 men	....	150	....	Net saving $4612.16	....
Post Hole Diggers																
51	....	400.00	20%	250.00 per Mo.	40.00 per Mo.	5	Gas	2 men	0.385 per hole	0.66 per hole	5 men	....	300	....	Economical	....
58	K	5000.00	2.00 per day	35.00	....	10	Fordson tractor	3 men	0.25 digging hole and setting pole	1.25 digging hole and setting pole.	....	....	250	....	Used for boring holes for automatic signal installation	....

NOTE: *9 men, includes 4 sprayers and 5 other workmen.

Appendix B

(3) STANDARDIZATION OF PARTS AND ACCESSORIES FOR RAILWAY MAINTENANCE MOTOR CARS

F. M. Thompson, Chairman, Sub-Committee; H. J. Armstrong, H. A. Cassil, C. C. Cook, F. B. Doolittle, John Evans, E. T. Howson, C. S. Joseph, J. B. Mabile, G. M. Strachan.

RULES FOR THE CARE OF MOTOR CARS

A conference was held during the year with a representative of Committee XII—Rules and Organization, and an agreement reached whereby "Rules for the Care of Motor Cars," proposed by your Committee and published in the Proceedings (Vol. 28, pages 297 and 298), together with an additional rule, would be substituted for the rules proposed by Committee XII, outlining "Duties of Motor Car Operators." It was agreed, further, that the classification "Motor Car Operator" should be changed to "Motor Car Repairman," as more descriptive of the duties of this position; and that due to the comparatively few employees coming within the scope of this classification, special rules for their guidance are unnecessary. These rules and change in classification will be included in the report of Committee XII.

STANDARDIZATION OF PARTS AND ACCESSORIES FOR RAILWAY MAINTENANCE MOTOR CARS

With the assistance of a committee composed of railway maintenance motor car supervisors, your Committee is still working with the motor car manufacturers' representatives on the standardization of parts and accessories for railway maintenance motor cars, and although considerable information has been developed, it is not felt that sufficient research work has been conducted to permit making definite recommendations to the Association. Therefore, your Committee reports progress, and recommends continuance of the subject for another year.

Appendix C

(4) EQUATING TRACK VALUES FOR LABOR DISTRIBUTION

F. S. Schwinn, Chairman, Sub-Committee; C. A. Ashbaugh, T. S. Bond, A. E. Botts, W. S. Burnett, H. M. Church, J. F. Dobson, F. B. Doolittle, C. H. R. Howe, Cale Wamsley.

Replies to inquiries addressed to a large number of railroads during the past two years indicate that about half of the railroads in this country have adopted the practice of equating track values, using all or a part of the list of comparative values or equivalents suggested in the 1922 report of this Committee and published on page 685, Vol. 23 of the Proceedings. The following items are most commonly used:

One mile of first main track is equivalent to:

1.15 miles of second main track,
1.33 miles of third or fourth main track,
2.00 miles of branch line track,
2.00 miles of passing and thoroughfare track,
3.33 miles of yard tracks,
12 main track switches,
20 side track switches.

Some of the carriers include other items, such as railroad crossings, city street crossings, county road crossings, track pans, ditches, fences, interlocking plants, derails, station grounds, water and fuel stations, stock pens and chutes, slides, etc., which are assigned various equivalent values.

It is thought that the items tabulated above are sufficient for all practical purposes in equating the physical property to equivalent main line miles and that additional equivalents made necessary by local conditions should be established by individual lines.

Your Committee appreciates that in addition to a summation of equated mileage found on the several divisions of a railroad, consideration must be given, in distributing labor, to the comparative present condition of each division, the condition to be ultimately attained, comparative volume of traffic, differences in climatic conditions, grades, curvature, drainage, and other features that would have a bearing on the amount of track labor required.

This Committee, as well as the Committee on Track (Vol. 18, page 420), has in previous years made analyses of the distribution of track labor for various classes of maintenance of way work. Such analyses, while interesting, do not point to definite conclusions as to proper percentages of track labor to be assigned for each operation. Here, again, the differences such as traffic, climate, location, age or physical condition of the property, and other factors, must govern.

An investigation was undertaken to determine the amount of track labor employed in roadway maintenance on railroads in the United States, based on Annual Reports of the Interstate Commerce Commission on Statistics of Railways, for the four years, 1923 to 1926, inclusive. From these statistics we have secured approximately accurate total of mileage, gross ton miles, and man-hours of track labor, by districts; converting the operated mileage and other property to a reasonably correct estimation of equated mileage, by using the equivalents hereinbefore referred to. The item of Track Labor was separated as between the accounts Roadway Maintenance, and Track Laying and Surfacing, and further divided as between that "Affected by Use" and "Not Affected by Use," in accordance with the recommendations of the Committee on Economics of Railway Operation (Vol. 24, page 1058).

The results of this investigation are set out in the following tabulations:

TRACK LABOR EMPLOYED ON ROADWAY MAINTENANCE (Account 202)
AND
TRACK LAYING AND SURFACING (Account 220)
CLASS I RAILROADS
YEARS 1923 TO 1926, INCLUSIVE

Track Labor Not Affected by Use, Per Equated Mile

	Man-Hours per Equated Mile per Year				
District	*1923*	*1924*	*1925*	*1926*	*Average*
Eastern	1,935.3	1,678.6	1,717.3	1,766.9	1,774.5
Southern	1,823.7	1,790.1	1,863.6	1,954.7	1,858.0
Western	1,321.5	1,209.6	1,165.2	1,246.9	1,235.8

Track Labor Affected by Use, per Million Gross Ton Miles

	Man-Hours per Million Gross Ton Miles				
District	*1923*	*1924*	*1925*	*1926*	*Average*
Eastern	264.7	259.2	245.8	248.8	254.6
Southern	301.2	296.5	288.7	277.1	290.9
Western	324.6	321.4	298.0	304.7	312.2

Average Number of Men (Including Foremen) per Working Day per Equated Mile During Four-Year Period (1923-1926)

District	*Not Affected by Use*	*Affected by Use*	*Total*
Eastern	0.72	0.49	1.21
Southern	0.76	0.47	1.23
Western	0.50	0.33	0.83

Average Number of Men (Including Foremen) Required per Working Day per Equated Mile

If Use on All Districts Equalled That on Eastern District

District	*Traffic Density Million Gross Ton Miles per Year per Equated Mile*	*Men Required If Traffic Density Equaled That of Eastern District*
Eastern	4.75	1.21
Southern	3.98	1.32
Western	2.57	1.11

An analysis of the foregoing tabulations indicates:

(a) Approximately 43 per cent more track labor "not affected by use" was worked per equated mile in the Eastern District, and 50 per cent more in the Southern, than was worked in the Western District.

(b) Track labor "affected by use," per million gross ton miles, was 14 per cent more in the Southern, and 21 per cent more in the Western, than was worked in the Eastern District.

(c) Upon converting man-hours to men (including foremen) worked per working day per equated mile, it was found that the amount of labor worked, both as "affected by use" and "not affected by use," was approximately 50 per cent more in the Eastern than in the Western District.

(d) If the traffic density in the Western and Southern Districts were increased to equal that of the Eastern District, the average number of men (including foremen) per working day per equated mile would be increased to the extent that it would equal that of the Eastern District.

Conclusion

For insertion in the Manual:

(1) RECOMMENDED PRACTICE FOR EQUATING THE PHYSICAL PROPERTY OF A RAILROAD TO EQUIVALENT MAIN LINE MILES

One mile of first main track is equivalent to:

1.15 miles of second main track,
1.33 miles of third or fourth main track,
2.00 miles of branch line track,
2.00 miles of passing and thoroughfare track,
3.33 miles of yard tracks,
12 main track switches,
20 side track switches.

To this list there may be added such other items as may be required, and the equivalents as so determined should be adjusted by factors relating to present condition, traffic density, speed of trains, seasonal or climatic conditions, grades, curvature, drainage, and the ultimate standard of maintenance desired.

(2) That this subject be closed.

Appendix D

(5) THE ECONOMIC RATIO OF SUPERVISION TO LABOR

H. A. Cassil, Chairman, Sub-Committee; C. A. Ashbaugh, C. C. Cook, J. A. Heaman, C. H. R. Howe, J. C. Patterson, H. M. Stout, W. H. Vance.

Your Committee has assembled data from representative railroads throughout this country and Canada, with an aggregate track milage of 112,035, regarding their Maintenance of Way employees, divided between supervision and labor. This includes the mileage of branch lines, side and yard tracks, etc. This mileage was reduced to total equated mileage, based upon the A.R.E.A. formula, resulting in an aggregate total of 159,464 equated miles, as shown in tabulated addenda.

Direct comparisons cannot be made in all cases, between various railroads, due to radically divergent local conditions, but the averages derived give valuable information from a sufficient number of widely varying railroads to form a suitable and reasonable basis for comparisons between individual lines and the average.

The data as to Track Supervisors and their Assistants, Section Foremen, Section Laborers and others, who have to do only with track work, can be reduced to direct comparisons.

In the case of Bridge and Building Supervisors, or Master Carpenters, the conditions vary to such an extent that it is impractical to make comparisons that would be of value. However, in this class of employment, as well as in other Maintenance of Way work, supervision must be kept in mind, particularly on account of changing conditions. Formerly, the work of Bridge and Building Supervisors, or Master Carpenters, was largely in the construction and maintenance of wooden structures, such as pile and frame trestles, etc., but with replacement of structures in more permanent form, the work of the Bridge and Building Department has changed rapidly and requires revision from time to time so that the proper ratio of supervision to labor will be maintained. Another element requiring consideration in Bridge and Building Department work is the construction of concrete culverts, abutments, piers, etc., which on some railroads is handled almost exclusively by contract, while on others is done by company forces.

A similar situation exists in the Signal and Telegraph Departments. The work in these departments increases each year, with the various installations of automatic train control, automatic signals, electric grade crossing protection, etc., and the ratio of supervision to labor must likewise be changed from time to time.

On many roads, for years back, six miles of main track has been considered a reasonable length for a track section, especially before the general use of section motor cars. It is interesting to note that the average section length on the railroads reporting is six miles, equated to include branch lines, side tracks, etc. Of course, it must be admitted that the length of sections varies with the traffic and importance of the division, and it undoubtedly varies on different parts of the same road. However, six miles is a general average for the whole.

A Track Supervisor is responsible for the maintenance of an average of 121 equated miles of track, and for the supervision of 18 section gangs (ranging from a maximum of 54 to a minimum of 4 gangs). The average section gang consists of 4 men, resulting in an average section force per Track Supervisor of 103 men. In addition, the average Track Supervisor has 1.4 extra gangs of 19 men, making a total average force per Supervisor of 19 foremen and 122 men. This does not, of course, include the supervision of work-trains and other special work.

A Bridge and Building Supervisor (or Master Carpenter) has supervision over an average of 8 Bridge and Building, Painter and Water Service Foremen (ranging from a maximum of 36 to a minimum of one foreman), and for a total average force of 70 foremen and employees (ranging from a maximum of 307 to a minimum of 5 foremen and employees.)

Summary

The organizations, as reflected by addenda to this report, have been built up through many years' of experience and in many instances were originally worked out in their present form when traffic was much lighter, speed slower, standards of maintenance less exacting, weight of equipment much less, and practically all maintenance of way work was performed by manual labor. With the reverse of these conditions and the use of labor-saving devices, which requires added supervision, and the varying conditions on different roads, it would be extremely difficult to establish a definite relation between supervision and labor that would be applicable to all railroads.

Conclusion

It is the conclusion of your Committee that the ratio of supervision to labor is an individual problem for each railroad, and that the data in this report be applied by making suitable equations for individual lines by those most familiar with their own requirements.

9		214	53			236	69		
1132c	3	310	5261	8	85	702	5316	8	10
11	613	1	12	12	1	0	54	1	152
18	8	1	10	10	0	1	9	0	0
193	8	3	32	2	0	1	52	0	43
449	8	11	29	2	4	50	24	12	103
60	11	1	32	32	1	1	3	3	0
300	3	3	52	9	4	0	42	6	[illegible]
52	4	0	3	0	0	0	1	[illegible]	34
35									
1181	9	6	39	6	1	33	0	3	40
501	6	3	18	0	0	3	13	10	21
213	3	8	61	1	1	11	151	0	0
2	0	0	0	0	0	0	0	0	0
50	50	0	1	0	0	0	[illegible]	[illegible]	0
39	12	1	8	0	1	0	0	1	[illegible]
349	0	1	500	53	0	3	3	[illegible]	93
16	2	0	0	0	0	1	1	4	[illegible]
99	4	4	12	4	1	1	43	23	160
80	6	4	[illegible]	4	5	0	12	3	[illegible]
326	6	0	21	0	0	0	0	2	[illegible]
1131	1	0	[illegible]	[illegible]	2	0	[illegible]	[illegible]	[illegible]
152	2	18	26	[illegible]	[illegible]	[illegible]	0	14	[illegible]
144	4	[illegible]	501	2	0	[illegible]	[illegible]	[illegible]	151
186	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
164	5	[illegible]	133	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
112	6	[illegible]	0	[illegible]	0	[illegible]	0	[illegible]	50
51	10	[illegible]	0	0	[illegible]	[illegible]	0	6	0
30	10	0	1	[illegible]	[illegible]	[illegible]	3	4	23
504	1	[illegible]	16	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]
811	0	1	[illegible]	2	0	14	80	1	[illegible]
81	6	[illegible]	8	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
599	[illegible]	2	79	[illegible]	0	0	[illegible]	36	[illegible]
120	4	[illegible]	16	9	[illegible]	[illegible]	10		[illegible]
13	1	5	19	0	1	[illegible]	10	[illegible]	[illegible]
10	10	[illegible]	0	0	0	0	1	0	
90	9	1	50	3	[illegible]	[illegible]	53	[illegible]	[illegible]
291	4	12	82	6	[illegible]	[illegible]	[illegible]	3	[illegible]
90	1	5	10	2	0	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]							

Questionnaire on the Economic Ratio of Supervision to Labor

Name of Railroad	Mileage of Main Track (Main 2nd and other multiple Trks)	Mileage of branches (Equated)	Mileage of Side & Yard Trks (Equated)	Equated Mileage all Tracks	Number of System and/or Grand Div Engrs of MofW (or Officers of like jurisdiction in charge of Maint)	Number of Division Engrs (or Officers of like jurisdiction in charge of Maint)	Number of Track Supervisors or Roadmasters	Number of Asst Track Supervisors or Asst Roadmasters	Number of Section Foremen	Average Number of Section Foremen per Track Supervisor or Road Master	Number of Section Laborers including Track Walkers	Average Number of Section Laborers per Section Foreman	Number of Extra Gang Foremen	Number of Extra Gang Laborers	Average Number Extra Gang Laborers per Extra Gang Foreman	Total Average Track Force per Track Supervisor or Road Master	Bridge and Building Supervisors or Road Masters	Number of Bridge and Building Foremen	Average Number B&B Foremen per B&B Supervisor	Number of B&B Carpenters and Helpers	Average Number B&B Carpenters and Helpers per B&B Foreman	Number of Painter Foremen	Number of B&B Painters and Helpers	Average Number B&B Painters per Painter Foreman	Number of Water Service Supervisors	Number of Water Service Foremen	Number of Water Service Mechanics and Helpers	Average Number of Foremen per B&B Supervisor or Master Carpenter	Total Average Force B&B Water Service Foremen and Employees per B&B Supervisor or Master Carpenter
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	c	d	4a		5a		4b	5g			3h	4a		5[illegible]		4g	5d		[illegible]	4f	5e		
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	5	3	30	6	[illegible]	0	[illegible]	35	0	1	0	8	8	0	0	[illegible]	0	[illegible]		[illegible]	[illegible]
[illegible] R R	[illegible]	[illegible]	4	280	[illegible]	[illegible]	2	0	31	15	139	5	2	11	30	146	1	5	4	35	3	1	2	1	[illegible]	1	2	[illegible]	45
[illegible] R R	[illegible]	[illegible]	193	[illegible]	[illegible]	[illegible]	43	5	113	15	3327	5	41	4[illegible]0	10	164	5	23	5	229	10	8	49	6	3	0	11	[illegible]	61
B[illegible] R R	[illegible]	17	74	[illegible]	[illegible]			0	117	25	400	3	0		0	103	0	3	0	68	22	1	18	18	0	0	0	0	3
Bessemer & Lake Erie RR	[illegible]	27	[illegible]	393	1		1	0	45	17	314	7	5	75	25	145	[illegible]	6	3	57	8	1	10	10	0	2	3	6	40
B[illegible] & [illegible] RR	[illegible]	598	[illegible]	[illegible]	1	7	[illegible]	1	1250	16	6606	5	234	2800	[illegible]	141	15	160	8	813	5	18	89	5	0	38	143	11	72
B[illegible] & Chicago Terminal RR		0	0	[illegible]	0	1	2	2	28	14	220	7	2	40	20	147	1	5	3	32	10	1	14	14	0	1	12	5	53
Bingham & Garfield Ry	20	[illegible]	[illegible]	[illegible]	0	[illegible]	1	1	4	4	100	25	1	50	5	155	3	1	0	6	6	1	3	3	0	3	0	0	[illegible]
[illegible] RR	[illegible]	113	135	147	1	[illegible]	4	5	105	26	793	7	5	165	10	200	2	2	1	36	18	2	20	13	[illegible]	[illegible]	0	2	1
Boston & Maine RR	1824	411	445	2685	4	5	16	[illegible]	334	22	2847	8	102	636	6	246	5	40	9	412	8	5	5[illegible]	6	0	[illegible]	84	1	[illegible]
Canadian National Rys	13803	4132	2343	[illegible]884	31	[illegible]	[illegible]	0	1144	22	11566	3	222	5615	26	132	43	351	8	1652	5	7	248	0	5	0	493	9	67
Central of Georgia Ry Co	1926	0	246	2172	1	4	13	1	246	13	1160	4	5	85	17	78	4	21	5	170	8	2	12	6	0	0	4	6	52
Central RR of New Jersey	[illegible]	36	278	[illegible]	0	2	5	5	160	32	1087	6	46	800	17	418	5	22	1	159	9	9	52	6	[illegible]	[illegible]	54	8	67
C[illegible]field RR C[illegible]	271	5	50	331	1	[illegible]	2	0	55	24	226	4	1	45	15	163	1	2	1	24	12	1	6	6	0	0	1	3	34
Chicago & Eastern Illinois Ry	235	45	217	1105	1	[illegible]	9	1	167	18	644	4	0	0	0	90	2	11	5	64	6	2	6	3	2	0	22	6	57
Chicago & Northwestern Ry Co	4341	2672	1269	[illegible]	1	3	11	0	1371	12	6630	5	20	[illegible]	45	145	23	147	5	1080	8	11	120	11	0	16	37	6	50
Chicago St Paul Minneapolis & Omaha Ry Co	[illegible]	[illegible]	126	[illegible]	[illegible]	1	8	1	305	36	1119	3	3	173	54	253	5	35	7	249	6	5	42	8	0	0	77	0	72
Cleveland Cincinnati Chicago & St Louis Ry Co	1723	123	506	[illegible]	7	5	25	0	504	17	2532	5	15	[illegible]	44	[illegible]	13	44	3	375	9	13	32	2	0	11	17	3	30
Denver & Rio Grande Western RR	1483	674	292	2359	5	[illegible]	15		268	18	1220	4	23	300	60	180	5	10	2	60	6	3	23	5	1	5	[illegible]	4	6
Delaware Lackawanna & Western RR	935	371	348	1654	6	3	9	13	264	[illegible]	1776	6	15	[illegible]	—	[illegible]	7	53	7	325	6	5	118	24	3	6	142	8	93
Elgin Joliet & Eastern Ry Co	210	29	255	494	2	[illegible]	5	2	69	25	688	5	4	180	45	311	1	15	13	85	6	2	16	0	0	2	8	17	126
Fort Smith & Western Ry	200	0	14	214	1	[illegible]	—	0	32	16	56	5	1	6	6	6	1	5	3	16	5	[illegible]	0	0	1		0	3	13
Fort Worth & Denver City Ry	457	134	69	66[illegible]	1		5	0	102	20	890	5	5	131	45	158	1	8	9	96	[illegible]	1	6	6	1	3	10	13	173
Florida East Coast Ry Co	869	155	157	1181	2	[illegible]	11	0	140	17	640	4	3	40	16	15	2	13	6	30	4	2	20	10	1	2	10	8	48
Georgia & Florida RR	256	25	14	359	1	0	3	0	45	15	135	3	1	12	12	64	1	2	1	7	1	0	0	0	1	1	2	7	7
Gulf Mobile & Northern RR	480	53	44	577	1	4	6	0	61	10	[illegible]	7		100	54	106	0	2	0	36	15	0	2	[illegible]	1	[illegible]	0	0	0
Gulf Coast Lines	1652	222	0	2074	2	3	17	1	136	10	[illegible]	6	28	935	34	127	5	17	5	286	12	10	20	2	5	[illegible]	15	5	53
Grand Trunk System	948	203	247	1398	1	3	7	0	[illegible]	28	88	4	17	844	47	211	3	16	5	121	7	4	25	6	1	1	33	5	68
Hocking Valley RR Co	455	22	132	589	1	0	6	1	53	15	570	6	18	251	14	155	1	11	11	11	1	1	10	10	1	2	4	14	41
Illinois Central RR	7746	0	1161	8907	1	11	86	0	1286	16	7221	5	104	1667	15	127	10	121	6	1200	10	18	107	6	16	16	163	8	51
Kansas City Southern Ry	815	35	163	1013	1	4	11	0	154	14	514	5	8	120	15	72	0	13	0	50	7	2	10	5	0	3	1		
Louisville & Nashville RR	4084	685	708	5477	1	21	31	0	1614	14	8702	6	86	1348	16	157	16	124	8	567	4	15	85	6	12	0	0	5	47
Lehigh Valley RR	1031	74	446	1551	1	5	15	1	331	22	544	2	0	0	0	02	6	17	3	90	9	7	24	3	0	6	23	2	61
Louisville Henderson & St Louis Ry	137	22	19	178	1	1	3	1	31	16	155	5	1	20	24	69	0	1	0	10	10	0	0	0	0	0	1	[illegible]	[illegible]
Maine Central RR Co	600	252	122	874	4	8	5	0	161	32	877	5	13	444	34	259	5	11	3	75	7	2	13	5	1	2	10	5	38
Michigan Central RR Co	1042	647	504	2153	4	11	19	15	482	25	2185	4	10	550	55	174	6	33	5	150	4	2	16	8	1	5	10	7	46
Minneapolis St Paul & Sault Ste Marie Ry	2195	1082	396	3673	10	5	32	2	549	18	1857	3	15	500	33	92	1	28	28	200	7	8	48	6	0	0	13	38	307
Minneapolis & St Louis RR Co	1368	27	126	1521	1	0	5	1	134	21	798	4	0	0	0	165	3	13	4	81	6	2	8	4	0	4	4	4	37
Missouri Pacific RR	4148	1620	834	6602	2	19	65	0	1247	15	4698	4	65	1355	24	113	19	111	6	877	8	7	38	5	0	14	89	7	63
Missouri-Kansas-Texas Lines	1621	704	429	2754	1	7	25	0	503	17	1565	4	8	288	36	95	5	26	5	204	7	4	18	4	3	6	18	8	34
Missouri & North Arkansas Ry	348	0	0	348	3	0	3	0	47	15	182	4	1	15	15	85	1	3	3	38	10	0	1	0	0	1	3	4	33
Mississippi Central RR	150	6	8	164	1	0	1	0	17	17	84	5	0	0	0	113	0	8	8	21	10	0	0	0	0	0	0	8	8
Nashville Chattanooga & St Louis Ry	747	250	165	1166	5	5	10	0	164	16	1110	7	9	301	32	158	5	13	2	115	5	0	0	0	0	5	0	5	26
New York Central (Buffalo & East)	3180	1094	1035	5309	1	11	37	55	880	21	5524	6	104	2511	23	236	11	180	16	467	2	17	192	11	0	11	135	19	51
New York Chicago & St Louis Ry Co	1923	17	265	2205	4	0	17	1	307	18	1648	5	28	286	14	134	4	31	8	156	5	6	16	3	2	5	22	10	56
New York New Haven & Hartford RR	2456	371	614	3390	2	5	28	12	476	17	2788	5	77	624	10	146	5	112	12	447	4	31	281	9	0	8	208	16	171
Northern Pacific Ry	3547	1709	912	6168	2	4	55	5	735	14	5122	4	48	941	15	85	11	115	10	621	5	18	56	3	0	23	0	14	75
Norfolk & Western Ry	2163	348	533	3044	18	4	23	14	334	17	2808	7	82	832	10	178	7	107	15	751	7	0	56	0	5	0	98	15	150
Pennsylvania RR (New Jersey Div)	855	172	325	1356	1	3	12	5	250	24	1637	5	74	660	9	221	3	45	15	266	6	0	57	0	0	0	0	15	116
Pere Marquette Ry	1470	429	485	2384	1	4	14	0	252	18	1024	4	4	100	25	98	5	12	2	60	6	4	15	4	2	0	18	3	26
Pittsburgh & Lake Erie RR	427	21	220	668	1	1	7	15	101	14	725	7	66	515	14	558	1	22	22	55	4	4	15	4	1	3	45	35	135
Pittsburgh & West Virginia Ry	85	4	23	112	0	1	1	0	24	20	73	3	0	0	0	93	1	6	3	16	5	0	0	0	0	1	1	4	81
Reading Co	2190	83	477	2750	1	7	21	7	489	23	3400	7	14	550	25	202	6	0	0	549	0	7	200	28	0	0	8	1	93
Richmond, Fredericksburg & Potomac RR	232	0	66	298	1	0	2	1	31	18	445	14	2	65	34	275	2	2	1	59	15	1	8	8	1	0	0	1	20
Sacramento Northern Ry	106	33	16	155	0	1	1	0	13	13	85	6	1	20	20	115	0	1	0	20	20	0	1	0	0	0	0	0	0
Spokane International Ry	141	10	12	163	1	0	1	1	17	17	60	5	1	30	20	98	1	0	0	5	0	0	0	0	0	0	8	0	5
St Louis & San Francisco Ry	3066	1073	534	4673	1	7	38	0	812	21	2691	3	28	347	12	102	0	39	0	373	5	8	61	7	7	11	101	0	0
St Louis Southwestern Ry	1171	151	197	1559	1	4	12	0	231	19	1159	5	9	240	26	156	4	33	8	201	6	3	16	6	0	3	12	10	67
Southern Railway System	8732	0	1227	9959	10	25	100	7	1422	14	6305	4	51	711	18	89	31	134	4	1181	8	6	30	6	1	33	0	5	45
Temiskaming & Northern Ontario Ry	252	58	46	356	1	1	3	0	71	23	331	4	7	200	28	198	1	6	6	29	4	0	2	0	0	0	1	8	34
Texas & Pacific Ry Co	1760	371	266	1857	1	4	15	2	261	17	2088	8	27	300	55	218	4	23	5	300	13	3	23	8	4	0	46	0	58
Terminal RR Association of St Louis	84	0	97	181	4	0	4	0	37	8	550	14	15	250	16	213	0	7	0	80	11	1	35	35	1	1	5	0	0
Union Pacific RR	3020	882	537	4439	1	6	21	1	621	20	3135	5	37	1730	47	178	6	51	8	449	8	11	55	5	4	23	54	19	107
Wabash Ry	2558	0	0	2586	1	11	83	0	483	17	1520	3	19	182	12	85	6	23	4	195	8	7	38	5	0	7	25	6	43
Wheeling & Lake Erie Ry	541	0	160	701	2	0	7	2	89	12	780	7	3	100	33	127	0	18	0	78	8	1	18	18	0	1	5	0	0
Name of Road withheld	316	39	112	467	0	1	1	5	54	54	425	8	2	38	15	521	1	6	8	77	13	1	15	15	1	0	24	7	133
TOTAL	112035	25018	22410	159464	171	337	1318	208	24768	18	111104	4	1028	37204	19	131	560	2471	7	17286	7	310	2541	8	88	303	2518	8	70
MILES PER MAN							121		6		1[illegible]						448	64		9		514	62			524	68		

Appendix E

(6) PRACTICAL EDUCATION AND TRAINING OF THE INDIVIDUAL WORKMAN IN HIS ASSIGNED DUTIES, AS A MEANS OF SECURING AN INCREASED OUTPUT AND BETTER QUALITY OF WORK, WITH LESS EFFORT AND FEWER ACCIDENTS

Lem Adams, Chairman, Sub-Committee; H. J. Armstrong, C. A. Ashbaugh, A. E. Botts, W. S. Burnett, Wm. Carpenter, J. A. Heaman, E. T. Howson, J. C. Patterson, Cale Wamsley.

Your Committee has solicited information from representative railroads, in the United States and Canada, of their practice in training and education of the individual workman in the Maintenance of Way Department. A great deal of information was received from the Federal Board for Vocational Education and from the Bureau of Labor Statistics, of the United States Department of Labor, and the Committee wishes to hereby express to these Bureaus its appreciation for their generous co-operation.

The accident prevention feature of this subject is exceptionally well covered on nearly all American railroads. It appears that all practical means are provided to safeguard maintenance of way employees in the conduct of their work. Safety appliances are provided on machines used by maintenance of way employes; tools are carefully inspected by foremen, to prevent injuries from flying particles of steel; goggles are worn by employees when any work is undertaken where material is likely to fly, thus protecting their eyes; and foremen are constantly on the alert to see that men do not engage in any practice in performing their work in a manner that might cause injury to themselves or their fellow workmen.

On most railroads, monthly or other periodic meetings are held on each division or other operating unit, which are attended by foremen, supervisory officers and other officials. These meetings are conducted solely for the purpose of promoting safety in all departments of railroad work. In addition, we have numerous National and International Associations studying accident prevention matters. Prominent among these are the National Safety Council and the Industrial Accident Prevention Conference, which devote a great deal of energy for promotion of safety for employees in all industries.

Among the earliest discourse of industrial safety, we find the statement: "A safe plant is an efficient plant." This thought has been expressed so repeatedly that it has become the working creed of safety experts. This principle applies equally as well to the scattered organization of a railroad Maintenance of Way Department as to the condensed and closely supervised departments of an industrial plant. When an employee is injured, he naturally loses more or less time from work, to which is added the lost time of fellow employees, who are distracted from their usual productive occupations. Moreover, a serious accident or the constant repetition of accidents, may temporarily, at least, lower the morale of the entire organization, which would be reflected in diminished production.

Most accidents are the result of contributing causes, not the least of which concern the personal element, such as lack of skill, inattention, improper supervision, fatigue, defective vision, and many others that affect both safety and productive efficiency. If any of these causes are eliminated, efficiency is thereby improved.

We do not find, however, the well developed organization for training and education of the individual workman in his assigned duties as is found in our Accident Prevention Department. In fact, there is little, if any, provision for the instruction of the novice in maintenance of way work, other than that imparted to him by his foreman. Therefore, we cannot expect to secure uniform methods of production under an arrangement of this kind. Even the supervisors on the same division will have different ideas of performing a given piece of work, and where the performance of work is left to such individual ideas, we certainly cannot expect that the best method will be followed.

Some railroads have schools for the education of workmen who desire to become foremen, or from whom it is expected that foremen will be made. However, the schools themselves are not ordinarily under the same supervision and, therefore, the foremen turned out in this manner probably have different ideas as to the method of performing their work.

The Chesapeake & Ohio Railway Company, as well as the St. Louis-San Francisco Railway Company, has gone very far into the study of methods of performing maintenance of way work, with a view toward securing detailed information and cost analysis on methods of performance, and should, with this intensive study, through close observation, develop some very useful and interesting data. Their method is to assign an Assistant Cost Engineer, who acts as Assistant Supervisor, on each Track Supervisor's district. The duties of this man are to keep an accurate cost of each operation performed by each section force. Through comparative figures, each section is given a monthly percentage rating on each operation performed, and each section foreman is informed as to the better methods as they are developed. Such studies should be of inestimable value to any maintenance of way organization, and should be copied by other railroads.

A general practice in breaking in a new man is to pair him with an experienced workman, where his pride is more or less tested, in order to adapt himself to his new work and keep up with his partner. He is, of course, assisted by the foreman as to doing his work correctly, expeditiously and safely. This provides a means for the new man to learn his work, but certainly would not produce a uniform method of performance.

On a number of lines, considerable attention is given to the program of maintenance work, to keep a uniform force employed and to avoid the general use of extra gangs. This provides a practical opportunity for a section foreman with a small gang to instruct his men in all classes of work, thus securing a more thorough individual training of track men. In some instances, education is confined more to hygienic lines, involving better housing and living conditions, with baths of hot and cold water, beautification and landscaping the surroundings, as well as other conveniences for the laborers and their families, in an effort to stimulate self-confidence and keep a better satisfied personnel, with ambition to remain in the service.

On many railroads, in the bridge and building and related departments, the training for increased output and better work on the part of laborers and mechanics is followed quite closely, and the results are indicated in periodical reports of work performed by the various gangs.

These reports are used as a means for comparing the relative output of one gang with another. It is a simple matter to establish average units of performance, and where the average performance is not equaled by individual gangs they are often taken to task. However, some very useful information could be obtained if the methods of performance were checked, and in the case of other gangs accomplishing more work than provided by the average unit, their methods could be carefully analyzed and applied to the gang that is not producing so efficiently.

It is also the custom on many railroads to have foremen's meetings where Maintenance of Way work is discussed for education in practical application of methods of performing work; adhering to standards; and a study of all problems confronting the track foreman. Such meetings tend to produce more uniformity in performance of work and, no doubt, increase the capacity and efficiency of the individual workman.

A number of railroads follow a general apprentice system in the Signal Department, whereby the workman starts in at a low rate of pay and is automatically stepped-up in pay each six months or each year for a period of approximately four years. Under this system, ordinarily, men are employed as helpers and promoted to assistant signalmen, and from assistant signalmen to signalmen or maintainers, after serving their full apprenticeship. During the apprenticeship period, they study general orders, rules and instructions as applied to railroad operation and especially the rules for the Signal Department, together with other pertinent information referring to their own work.

In this Committee assignment, the thought embodied was that certain rules and instructions should be provided for the proper method in handling various maintenance of way tools and materials. While such rules would need to be of a general nature, they would be of considerable help in establishing uniform methods.

There is a large field to be covered for special training of Maintenance of Way employees, particularly in the Track Department, and it should be the duty of every maintenance organization to study the best methods of performing each item of work, with a view toward securing the best practices, and have these standardized. The gang foreman is, of course, the individual on whom we must rely for the impartation of knowledge to his men. Therefore, the foreman must be taught the safe and efficient methods of performing his work. Due to isolation from close contact with his superiors, the foreman must constantly act on his own initiative. Therefore, it is extremely important that he is not too greatly handicapped with hard and set rules governing the performance of his work.

Summarizing, your Committee feels that a great improvement is badly needed and can be made in the instruction of embryo mechanics in the Maintenance of Way Department. It is our thought that an efficient track employee is a tradesman, experienced in the use of a large variety of tools and trained in placing various kinds of material, under changing conditions of traffic, foundation and climate. A track laborer should have at least two years' experience to become proficient in this kind of work, and to acquire proficiency in this length of time he must have exceptional opportunities and be unusually apt and willing to learn.

This subject is of such general nature that your Committee does not consider it advisable to make definite recommendations for standard methods of performing each item of Maintenance of Way work; therefore, it is recommended that the foregoing report be accepted as information and the assignment continued for further study.

REPORT OF COMMITTEE VII—WOODEN BRIDGES AND TRESTLES

W. E. Hawley, *Chairman;*
J. B. Maddock, *Vice-Chairman;*
H. Austill,
F. E. Bates,
E. H. Brown,
C. H. Chapin,
C. R. Chevalier,
F. H. Cramer,
A. F. Frendberg,
S. F. Grear,
R. P. Hart,
Reubin Hayes,
A. H. Henckel,
W. B. Hodge,
C. J. Hogue,
R. W. Kennedy,
R. E. Miller,
J. A. Newlin,
H. Norris,
C. E. Paul,
G. W. Rear,
Arthur Ridgway,
J. R. Sexton,
D. W. Smith,
M. A. Stainer,
G. C. Tuthill,
J. L. Vogel,
Wm. Walkden,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

Revision of Manual.

The report of the Sub-Committee on Revision of Manual will be found in Appendix A.

2. Continue work on simplification of grading rules and classification of timber for railway uses, collaborating with other organizations dealing with this subject.

The report of the Sub-Committee on this subject will be found in Appendix B.

3. Study and report advantage of establishing supply yards for standard trestle timbers at various locations throughout the country.

The report of the Sub-Committee on this subject will be found in Appendix C. A progress report was made on this subject last year and a final report is offered by the Sub-Committee.

4. Study and report on standardization and simplification of store stock and disposition of material reaching obsolescence, collaborating with other committees and organizations concerned.

This assignment covers a very large and broad subject in which the railroads have already made many advances. There is a chance for some very interesting accounts of what has been done and the possibility of outlining the methods and economies which would ensue from a systematic study. The Committee desires further time and asks that the subject be reassigned to the Committee for the coming year's work.

5. Study and report on overhead wooden bridges.

The Sub-Committee on this subject offers a progress report and has outlined further work in Appendix D.

Bulletin 314, February, 1929.

Recommendations for Future Work

The recommended suggestions for future work of the Committee are therefore as follows:

1. Revision of Manual.
2. Continue work on simplification of grading rules and classification of timber for railway uses, collaborating with other organizations dealing with this subject.
3. Study and report on the standardization and simplification of store stock and disposition of material reaching obsolescence, collaborating with other committees and organizations concerned.
4. Study and report on overhead wooden bridges.
5. Outline of work for ensuing year.

Action Recommended

1. That the revisions of the Manual offered in Appendix A be adopted by the Association.
2. That the revisions offered in Appendix B be accepted by the Association as information for the Proceedings and the subject-matter covered by this revision be withdrawn from Manual. Cross reference shall be provided by suitable note in Manual, giving page of Proceedings.
3. That the report in Appendix C be accepted by the Association as information and the subject dropped.
4. That the other report be received as progress and the subjects continued as noted.

Respectfully submitted,

THE COMMITTEE ON WOODEN BRIDGES AND TRESTLES,

W. E. HAWLEY, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

H. Austill, Chairman, Sub-Committee; F. H. Cramer, C. J. Hogue, J. A. Newlin, C. E. Paul, Arthur Ridgway, G. C. Tuthill.

The Sub-Committee on Revision of Manual has made a number of changes in the Grading Rules for Classification of Timber and Lumber for Railway Uses.

It is recommended that the revised version be substituted for that heretofore adopted.

GRADING RULES AND CLASSIFICATION OF TIMBER AND LUMBER FOR RAILWAY USES

COMMERCIAL NAMES FOR LUMBER AND TIMBER CUT FROM THE PRINCIPAL SPECIES OF SOFTWOODS

The following standard commercial names for lumber and timber cut from species of softwood as listed under botanical names shall be used in the construction of contracts and other documents arising in transactions of purchase and sale of American Standard Lumber. Preferred commercial names are underscored.

Commercial Name	*Botanical Name*
	Cedars and Junipers
<u>Alaska Cedar</u>	Chamæcyparis nootkatensis
<u>Eastern Red Cedar</u>	Juniperus virginiana, Juniperus lucayana (southern red cedar) and Juniperus Mexicana (mountain juniper)
<u>Incense Cedar</u>	Libocedrus decurrens
<u>Northern White Cedar</u>	Thuja occidentalis
<u>Port Orford Cedar</u>	Chamæcyparis lawsoniana
<u>Southern White Cedar</u>	Chamæcyparis thyoides
<u>Western Juniper</u>	Juniperus utahensis (Utah juniper), Juniperus pachyphloea (alligator juniper), Juniperus scopulorum (Rock Mt. red cedar), and Juniperus occidentalis (western juniper)
<u>Western Red Cedar</u>	Thuja plicata
	Cypress
<u>Red Cypress</u>	Taxodium distichum (Coast type)
<u>Yellow Cypress</u>	Taxodium distichum (Inland type)
<u>White Cypress</u>	Taxodium distichum (Inland type)

Commercial Name	Botanical Name
	Douglas Fir
DOUGLAS FIR	Pseudotsuga taxifolia (Coast type)
RED FIR	Pseudotsuga taxifolia (Intermountain type)
RED FIR	Pseudotsuga taxifolia (Rocky Mountain type)
	The True Firs
ALPINE FIR	Abies lasiocarpa
BALSAM FIR	Abies balsamea and Abies fraseri (Southern balsam fir)
GOLDEN FIR	Abies magnifica
NOBLE FIR	Abies nobilis
SILVER FIR	Abies amabilis
WHITE FIR	Abies concolor and Abies grandis (lowland white fir)
	Hemlocks
EASTERN HEMLOCK	Tsuga canadensis and Tsuga Caroliniana (Carolina hemlock)
MOUNTAIN HEMLOCK	Tsuga mertensiana
WEST COAST HEMLOCK	Tsuga heterophylla
	Larch
WESTERN LARCH	Larix occidentalis
Commercial Name	*Botanical Name*
	Pines
ARKANSAS SOFT PINE	Pinus echinata and taeda
CALIFORNIA WHITE PINE	Pinus ponderosa and Pinus jeffreyi (Jeffrey pine)
IDAHO WHITE PINE	Pinus monticola
JACK PINE	Pinus banksiana
Loblolly Pine	Pinus taeda
LODGEPOLE PINE	Pinus contorta
Longleaf Pine	Pinus palustris
NORTH CAROLINA PINE	Pinus taeda and echinata, and Pinus Virginiana (Virginia Pine)
NORTHERN WHITE PINE	Pinus strobus
NORWAY PINE	Pinus resinosa
Pond Pine	Pinus rigida serotina
PONDOSA PINE	Pinus ponderosa
Shortleaf Pine	Pinus echinata
Slash Pine	Pinus caribaea
SOUTHERN PINE	Pinus taeda, palustris, serotina, echinata, and caribaea, and Pinus rigida (pitch pine) and Pinus glabra (spruce pine)
SUGAR PINE	Pinus lambertiana
	Redwood
REDWOOD	Sequoia sempervirens

Spruces

EASTERN SPRUCE	Picea mariana (black spruce), Picea rubra (red spruce), and Picea glauca (white spruce)
ENGELMANN SPRUCE	Picea engelmanni and Picea parryana (blue spruce)
SITKA SPRUCE	Picea sitchensis

Tamarack

TAMARACK	Larix laricina
PACIFIC YEW	Yew taxus brevifolia

USE CLASSIFICATION

Lumber is the product of the saw and planing mill not further manufactured than by sawing, resawing, and passing lengthwise through a standard planing machine, crosscut to length, and matched.

Lumber is classified as (a) yard lumber, (b) structural timbers, and (c) shop or factory lumber. Different grading rules apply to each class of lumber.

Yard lumber is lumber that is less than five (5) inches in thickness and is intended for general building purposes. The grading of yard lumber is based upon the use of the entire piece.

Structural timber is lumber that is five (5) inches or over in thickness and width. The grading of structural timbers is based upon the strength of the piece and the use of the entire piece.

Shop or factory lumber is lumber intended to be cut up for use in further manufacture. It is graded on the basis of the percentage of the area which will produce a limited number of cuttings of a given minimum size and quality.

SIZE CLASSIFICATION

Yard Lumber

Strips are yard lumber less than two (2) inches thick and under eight (8) inches wide.

Boards are yard lumber less than two (2) inches thick, eight (8) inches or over in width.

Dimension includes all yard lumber except boards, strips and timbers, that is, yard lumber two (2) inches and under five (5) inches thick, and of any width.

Planks are dimension lumber two (2) inches and under four (4) inches thick and eight (8) inches and over wide.

Scantlings are dimension lumber two (2) inches and under five (5) inches thick and under eight (8) inches wide.

Heavy joists are dimension lumber (4) inches thick and eight (8) inches or over wide.

Structural timbers are lumber five (5) inches or larger in least dimension.

MANUFACTURING CLASSIFICATION

Manufactured lumber is classified as rough, surfaced, and worked.

Rough lumber is undressed lumber as it comes from the saw.

Surfaced lumber is lumber that is dressed by running through a planer. It may be surfaced on one side (S1S), two sides (S2S), one edge (S1E), two edges (S2E), or a combination of sides and edges (S1S1E) (S2S1E) (S1S2E) or (S4S).

Worked lumber is lumber which has been run through a matching machine, sticker or molder. Worked lumber may be matched, shiplapped or patterned.

Matched lumber is lumber that is edge dressed and shaped to make a close tongue and groove joint at the edges or ends when laid edge to edge or end to end.

Shiplapped lumber is lumber that is edge dressed to make a close rabbetted or lapped joint when laid edge to edge.

Patterned lumber is worked lumber that is shaped to a patterned or moulded form.

DEFINITIONS OF MAXIMUM DEFECTS AND BLEMISHES

The following definitions vary slightly from the definitions of the American Lumber Standards. Definitions of regional lumber associations also vary slightly from American Lumber Standards. This should be considered in making contracts.

The terms "Defect" and "Blemish" as applied to wood usually imply the idea of imperfections. These are not always detrimental.

DEFECT.—Any irregularity or want occurring in or on wood that may lower some of its strength, durability or utility values.

BLEMISH.—Any mark or formation of wood structure, not classified as a defect, marring the appearance of the wood.

The presence of a defect or blemish may or may not be detrimental to the value of the material, depending upon the character of the defect or blemish and the use of the material.

Bark Pocket

BARK POCKET.—A patch of bark partially or wholly enclosed in the wood. In size it is classified the same as pitch pockets.

Bird's-eye

"BIRD'S-EYE."—A small central spot with the wood fibers arranged around it in the form of an ellipse, so as to give the appearance of an eye. "Bird's-Eye," unless unsound or hollow, shall not be considered a defect.

Checks

CHECK.—A lengthwise separation of the wood, which occurs usually across the rings of annual growth.

Surface Check.—A check occurring on the surface of the piece.

Small Surface Check.—A perceptible opening not over four (4) inches long.

Medium Surface Check.—A check not over $\frac{1}{32}$ inch wide and over four (4) but not more than ten (10) inches long

Large Surface Check.—A check over $\frac{1}{32}$ inch wide and over ten (10) inches long.

End Check.—Check occurring on an end of a piece.

Through Check.—Check extending from one surface through the piece to the opposite surface or to an adjoining surface.

Heart Check.—Check starting at the pith and extending toward but not to the surface of a piece.

Honeycombing.—Checks occurring in the interior of a piece, often not visible on the surface. On a cross-section they usually appear as slits, or as open pockets whose width may appear very large in proportion to the radial length.

Cross Breaks

Cross Break.—A separation of the wood cells across the grain, such as may be due to tension resulting from unequal shrinkage or mechanical stresses.

Cross Grain

Cross Grain.—Wood in which the cells or fibers do not run parallel with the axis, or sides, of a piece. It may be classified as spiral, diagonal, wavy, dip, curly and interlocked grain. The slope of the grain can be determined by observing the direction of surface checks, resin ducts, pores of the wood, annual layers of growth, etc. A drop of stained liquid, such as ink, tends to elongate in the direction of the grain when placed on a smooth surface of the piece.

Spiral Grain.—Wood in which the fibers take a more or less winding or spiral course, such as occurs in a twisted tree. It may be detected on the flat grain (plain sawed or tangential) surface.

Diagonal Grain.—Wood in which the fibers extend at an angle (i. e., diagonally) across a piece as a result of sawing at an angle across the annual layers of growth. It may appear on either the radial or tangential surface.

Wavy Grain.—Wood in which the fibers take the form of waves or undulations as indicated by the wavy surface of the split piece. It may appear on either the radial or tangential surfaces.

Dip Grain.—Wood which has one wave or undulation of the fibers such as occurs around knots, pitch pockets, etc.

Curly Grain.—Wood in which the fibers are distorted so that they take a curled direction as in "Bird's-Eye Wood." These patches may vary up to several inches in diameter.

Interlocked Grain.—Wood which shows spiral grain in one direction for a number of years and then the slope of the grain in the succeeding annual layers of growth turns in a reverse direction around the tree, then later reverses back, etc.

Slight Cross Grain.—Wood in which slope of the grain is not over one (1) inch in a length of fifteen (15) inches.

Medium Cross Grain.—Wood in which slope of the grain is over one (1) inch in a length of fifteen (15) inches but not more than one (1) inch in a length of ten (10) inches.

Steep Cross Grain.—Wood in which slope of the grain is over 1 inch in a length of 10 inches.

Decay

Decay.—A disintegration of wood substance due to the action of wood-destroying fungi. The words "dote" and "rot" mean the same as decay.

Incipient Decay.—An early stage of decay in which the disintegration has not proceeded far enough to soften or otherwise change the hardness of the wood perceptibly. It is usually accompanied by a slight discoloration or bleaching of the wood.

Firm Red Heart.—A stage of incipient decay characterized by a reddish color produced in the heartwood, which does not unfit the wood for the majority of yard purposes.

Water-Soak (or Stain).—A term applied to a generally water-soaked area in heartwood, which is usually interpreted as the incipient stage of certain wood rots.

Advanced (or typical) Decay.—The older stage of decay in which the disintegration is readily recognized because the wood has become punky, soft and spongy, stringy, ringshaked, pitted or crumbly. Decided discoloration or bleaching of the rotted wood is often apparent.

Pocket Rot.—Typical decay which appears in the form of a hole, pocket, or area of soft rot, usually surrounded by apparently sound wood.

Sound Wood.—Wood free from any form of decay, incipient or advanced, including firm red heart, dote and rot.

Gum Spots and Streaks

Gum Spot or Streak.—An accumulation of gum-like substance occurring as a small patch or streak in a piece. They may occur in conjunction with a bird peck, or other injury to the growing wood. In size they are classified the same as pitch pockets or pitch streaks.

Holes

Holes in wood may extend partially or entirely through the piece and be from any cause.

When holes are permitted, the average of the maximum and minimum diameters measured at right angles to the direction of the hole shall be used in measuring the size, unless otherwise stated.

Pin worm hole—One not over $\frac{1}{16}$ inch in diameter.

Medium worm hole—One over $\frac{1}{16}$ but not more than $\frac{1}{4}$ inch in diameter.

Large worm hole—One over $\frac{1}{4}$ inch in diameter.

Imperfect Manufacture

Imperfect manufacture includes all defects or blemishes which are produced in manufacturing, such as chipped grain, loosened grain, raised grain, torn grain, skips in dressing, hit and miss, variation in sawing, mis-cut lumber, machine burn, machine gouge, mismatching and insufficient tongue or groove.

CHIPPED GRAIN.—A part of the surface chipped or broken out in very short particles below the line of cut. It should not be classed as torn grain and, as usually found, shall not be considered a defect, unless it is present in excess of 25 per cent of the area.

LOOSENED GRAIN.—A small portion of the wood which has become loosened but not displaced. It occurs on the heartside of the piece and is a serious defect, especially in flooring.

RAISED GRAIN.—A roughened condition of the surface of dressed lumber in which the hard summerwood is raised above the softer springwood, but not torn loose from it.

TORN GRAIN.—A part of the wood which is torn out in dressing, and in depth is of four distinct characters; slight, medium, heavy and deep.

SLIGHT TORN GRAIN.—Not more than $\frac{1}{32}$ inch in depth.

MEDIUM TORN GRAIN.—More than $\frac{1}{32}$ but not more than $\frac{1}{16}$ inch in depth.

HEAVY TORN GRAIN.—More than $\frac{1}{16}$ but not more than $\frac{1}{8}$ inch in depth.

DEEP TORN GRAIN.—More than $\frac{1}{8}$ inch in depth.

SKIP.—An area on a piece that failed to surface.

SLIGHT SKIP.—One that failed to surface smoothly, whose area does not exceed the product of the width of the piece in inches multiplied by six (6).

HEAVY SKIP.—One that the planer knife did not touch.

HIT AND MISS.—A series of skipped spots with surfaced areas between, or with skips the entire length when not over $\frac{1}{16}$ inch in depth.

VARIATION IN SAWING.—A deviation from the line of cut.

SLIGHT VARIATION.—Not more than $\frac{1}{16}$ inch in one-inch material, $\frac{1}{8}$ inch in 2-inch, $\frac{3}{16}$ in 3 to 7-inch, and $\frac{1}{4}$ inch in 8 inches and up.

MISCUT LUMBER.—That which has a greater variation in thickness or width at different places on the piece than specified for variation in sawing.

MACHINE BURN.—A darkening or charring of the wood due to overheating by the machine knives.

MACHINE GOUGE.—A groove across a piece due to the machine cutting below the desired line of cut.

MISMATCHED MATERIAL.—Worked material that does not fit tightly at all points of contact between adjoining pieces, or in which the surfaces of adjoining pieces are not in the same plane.

SLIGHT MISMATCH.—A surface variation not more than $\frac{1}{64}$ inch.

MEDIUM MISMATCH.—A surface variation more than $\frac{1}{64}$ but not more than $\frac{1}{32}$ inch.

HEAVY MISMATCH.—A surface variation more than $\frac{1}{32}$ inch.

Knots

KNOT.—A portion of a branch or limb which has become incorporated in the body of the tree. Knots are classified according to size, form, quality and occurrence. They are measured on the surface of the piece. The average of the maximum and minimum diameters shall be used in measuring the size of knots, unless otherwise stated.

Size

PIN KNOT.—One not more than ½ inch in diameter.

SMALL KNOT.—One more than ½ inch but not more than ¾ inch in diameter.

MEDIUM KNOT.—One more than ¾ inch but not more than 1½ inches in diameter.

LARGE KNOT.—One more than 1½ inches in diameter.

Form

ROUND KNOT.—One oval or circular in form.

SPIKE KNOT.—A branch or limb sawed in a lengthwise direction.

Quality

SOUND KNOT.—One solid across its face, as hard as the surrounding wood, and showing no indications of decay. It may vary in color from red to black.

UNSOUND KNOT.—One solid across its face but containing incipient decay.

DECAYED KNOT.—One softer than the surrounding wood and containing advanced decay.

TIGHT KNOT.—One so fixed by growth or position that it will firmly retain its place in the piece.

INTERGROWN KNOT.—One whose rings of annual growth are completely intergrown with those of the surrounding wood.

WATERTIGHT KNOT.—One whose rings of annual growth are completely intergrown with those of the surrounding wood on one surface of the piece, and which is sound on that surface.

ENCASED KNOT.—One whose rings of annual growth are not intergrown and homogeneous with those of the surrounding wood. The encasement may be partial or complete; or pitch or bark.

LOOSE KNOT.—One not held firmly in place by growth or position and which cannot be relied upon to remain in place in the board.

PITH KNOT.—A sound knot with a pith hole not more than ¼ inch in diameter.

HOLLOW KNOT.—An apparently sound knot with a relatively large hole in it.

Occurrence

SINGLE KNOT.—One occurring by itself with the fibers of the wood in which it occurs deflected around it.

KNOT CLUSTER.—Two or more knots grouped together as a unit with the fibers of the wood deflected around the entire unit. A group of single knots is not a knot cluster.

BRANCH KNOTS.—Two or more knots branching from a common center.

Pitch

Pitch.—A poorly defined accumulation of resin in the wood cells in a more or less irregular patch.

Light Pitch.—Lightly evident presence of pitch.

Medium Pitch.—Slightly more evident trace of pitch than the light pitch.

Heavy Pitch.—Very evident presence of pitch showing by its color and consistency.

Massed Pitch.—A clearly defined accumulation of solid pitch in a body by itself in a piece of lumber.

Pitch Pockets

Pitch Pocket.—A well defined opening between rings of annual growth usually containing, or which has contained, more or less pitch, either solid or liquid. Bark also may be present in the pocket.

Very Small Pitch Pocket.—One not more than ⅛ inch in width and not over two (2) inches in length.

Small Pitch Pocket.—One not more than ⅛ inch in width and not more than 4 inches in length, or not more than ¼ inch in width and not more than 2 inches in length.

Medium Pitch Pocket.—One not more than ⅛ inch in width and not more than 8 inches in length, or not more than ⅜ inch in width and not more than 4 inches in length.

Large Pitch Pocket.—One whose width or length exceeds the maximum stated as permissible for a medium pitch pocket.

Closed Pitch Pocket.—One that does not show an opening on both sides of the piece.

Pitch Seam

Pitch Seam.—A shake or check which is filled with pitch.

Pitch Streaks

Pitch Streak.—A well-defined accumulation of pitch in a more or less regular streak.

Small Pitch Streak.—One not more than 1/12 the width by 1/6 the length of the surface on which it occurs.

Medium Pitch Streak.—One more than 1/12 but not more than 1/6 the width, by over 1/6 but not more than 1/3 the length of the surface on which it occurs.

Large Pitch Streak.—One more than 1/6 the width by 1/3 the length of the surface on which it occurs.

Pith

Pith.—The small soft core occurring in the structural center of the log. The wood immediately surrounding the pith often contains small checks, shake, or numerous pin knots, and is discolored; any such combination of defects and blemishes is known as heart center.

Pith Fleck

Pith Fleck.—A narrow streak resembling pith, usually brownish, up to several inches in length on the surface of a piece resulting from burrowing of larvæ in the growing tissue of the tree.

Shake

Shake.—A lengthwise separation of the wood, which occurs usually between and parallel to the rings of annual growth.

Fine Shake.—One with a barely perceptible opening.

Slight Shake.—One with more than a perceptible opening but not more than $\frac{1}{32}$ inch in width.

Medium Shake.—One with an opening more than $\frac{1}{32}$ but not more than $\frac{1}{8}$ inch width.

Open Shake.—One with an opening more than $\frac{1}{8}$ inch wide.

Through Shake.—One extending from one surface through the piece to the opposite surface or to an adjoining surface.

Splits

Split.—A lengthwise separation of the wood, due to the tearing apart of the wood cells.

Short Split.—One whose length does not exceed either the width of a piece or 1/6 its length.

Medium Split.—One whose length exceeds the width of a piece, but does not exceed 1/6 its length.

Long Split.—One whose length exceeds 1/6 the length of a piece.

Stain (or Discoloration)

Stain.—Discoloration, occurring on or in lumber, of any color other than the natural color of the piece on which it appears. It is classified as light, medium and heavy.

Light Stain.—A slight difference in color which will not materially impair the appearance of the piece if given a natural finish.

Medium Stain.—A pronounced difference in color which, although it does not obscure the grain of the wood, would customarily be objectionable in a natural but not in a painted finish.

Heavy Stain.—A difference in color so pronounced as practically to obscure the grain of the wood.

Wane

Wane.—Bark, or lack of wood, from any cause, on the edge or corner of a piece.

Slight Wane.—Not more than $\frac{1}{4}$ inch wide on the surface on which it appears, for 1/6 the length and $\frac{1}{4}$ the thickness of the piece.

Medium Wane.—More than $\frac{1}{4}$ inch but not more than $\frac{1}{2}$ inch wide on the surface on which it appears, for 1/6 the length and $\frac{1}{4}$ the thickness of the piece.

Large Wane.—More than ½ inch wide on the surface on which it appears, and/or over 1/6 the length and ¼ the thickness of the piece.

Warp

Warp.—Any variation from a true or plane surface. It includes bow, crook, cup, or any combination thereof.

Bow.—Deviation flatwise from a straight line drawn from end to end of a piece, measured at the point of greatest distance from the straight line.

Crook.—Deviation edgewise from a straight line drawn from end to end of a piece, measured at the point of greatest distance from the straight line. It is known as slight, small, medium and large.

Based on a piece 4 inches wide and 16 feet long, the distances for the different degrees of crook shall be for:

Slight crook, a maximum of 1 inch.
Small crook, a maximum of 1½ inches.
Medium crook, a maximum of 3 inches.
Large crook, more than 3 inches.

For wider pieces it shall be ⅛ inch less for each additional 2 inches of width. Shorter or longer pieces may have the same curvature.

Cup.—A curve in a piece across the grain or width of a piece. It is measured at the point of greatest deviation from a straight line drawn from edge to edge of a piece. It is known as slight, medium and deep.

Based on a piece 12 inches wide, the distances for the different degrees of cup shall be for:

Slight cup, a maximum of ¼ inch.
Medium cup, a maximum of ⅜ inch.
Deep cup, a maximum of ½ inch.

Narrower or wider pieces may have the same curvature.

AMERICAN LUMBER STANDARDS FOR SOFTWOOD LUMBER

Classification

1. For the purposes of simplification of sizes and grades, and of equalizing, among species used for similar general purposes, the grades of a similar name, lumber shall be classified by principal uses into (a) yard lumber, (b) structural timbers, (c) shop or factory lumber.

Note.—See definitions for further details of various kinds of lumber.

Yard Lumber

2. The term "yard lumber" as here used means lumber that is manufactured and classified into those sizes, shapes, and qualities required for ordinary construction and general purpose uses. Heavy timbers for structural purposes, softwood factory lumber, hardwood factory lumber, and other special-use materials are not considered yard stock.

GRADE STANDARDS

Grades

3. On the basis of quality, yard lumber is divided into two main divisions: (a) Select lumber, and (b) Common lumber.

These are again divided into two classes—

Select lumber into

(1) that suitable for natural finishes and

(2) that suitable for paint finishes;

Common lumber into

(1) that which can be used without waste and

(2) that which permits some waste. Each of these four classes is further divided into quality classes or grades.

SELECT LUMBER

Select Lumber

4. Lumber which is generally clear, containing defects limited both as to size and number and which is smoothly finished and suitable for use as a whole for finishing purposes or other uses in which large, clear pieces are required, shall be considered Select Lumber.

5. Two classes shall be recognized. The first shall be suitable for natural finishes. The second class permits similar defects, and, in addition, blemishes of somewhat greater extent than those of the first class, but of a type which can be covered by paint.

Grade names are A, B, C, and D.

COMMON LUMBER

Common Lumber

6. Lumber containing numerous defects and blemishes which preclude it from use for finishing purposes, but which is suitable for general utility and construction purposes shall be considered Common Lumber.

7. Two general classes shall be recognized. The first shall be suitable for use as a whole for purposes in which surface covering or strength is required. Defects and blemishes permitted in this class must be sound. The second class permits very coarse defects which may cause waste in the use of the piece.

Board Grade Names: No. 1 Common, No. 2 Common, No. 3 Common, No. 4 Common, and No. 5 Common.

Dimension Grade Names: No. 1 Common, No. 2 Common, and No. 3 Common.

BASIC GRADE CLASSIFICATION FOR YARD LUMBER

8.

- Total products of a typical log arranged in series according to quality as determined by appearance.
  - SELECT: Lumber of good appearance and finishing qualities
    - Suitable for natural finishes
      - Grade A—Practically free from defects.
      - Grade B—Allows a few small defects or blemishes.
    - Suitable for paint finishes
      - Grade C—Allows a limited number of small defects or blemishes that can be covered with paint.
      - Grade D—Allows any number of defects or blemishes which do not detract from a finish appearance, especially when painted.
  - COMMON: Lumber containing defects or blemishes which detract from a finish appearance but which is suitable for general utility and construction purposes
    - Lumber suitable for use without waste
      - No. 1 Common—Sound and tight knotted stock. Size of defects and blemishes limited. May be considered watertight lumber.
      - No. 2 Common—Allows large and coarse defects. May be considered grain-tight lumber.
    - Lumber permitting waste
      - No. 3 Common—Allows larger and coarser defects than No. 2 and occasional knot holes.
      - No. 4 Common—Low quality lumber admitting the coarsest defects such as rot and holes.
      - No. 5 Common—Must hold together under ordinary handling.

Refer to Regional Associations

9. With the above as a basis the various regional lumber manufacturer's associations have published grading rules in detail for their products and reference should be made to these rules in interpreting the practical application of these divisions of lumber into quality classes.

10. As in the case of definitions, some of the provisions vary slightly from the American Lumber Standards and the particular rules under which shipment is to be made should be considered in making contracts.

GENERAL PROVISIONS

Inspection Rules Not Arbitrary Rules

11. No arbitrary rules for the inspection of lumber can be maintained with satisfaction. The variations from any given rule are numerous and suggested by practical common sense, so nothing more definite than the general features of different grades should be attempted by rules of inspection.

Variation in Grading and Inspection

12. The grading of lumber cannot be considered an exact science, because it is based on a visual inspection of each piece and on the judgment of the grader. The provisions of these specifications, however, are sufficiently explicit to establish 5 per cent below grade as a reasonable variation between graders.

Suitability for Use

13. All yard lumber is graded with reference to its suitability for general use as yard lumber. With this in view, each piece is considered and its grade determined by its general character, including the location and sum of all of its defects and blemishes. Material not conforming to standard sizes or grades shown herein and that intended for special uses, shall be covered by special contract and inspection.

Better Face

14. Except in dimension, the grade of yard lumber, rough or surfaced two sides, shall be determined from the better or face side of the piece,

Surfaced Face

and lumber which is surfaced one side only shall be graded from the surfaced side.

Poorest Piece

15. The rules for yard lumber prescribe the number and extent of defects and blemishes in the poorest pieces admissible in each grade. A grade should be representative, however, and not made up of only low line pieces.

Area of Piece

16. The number of defects and blemishes permitted varies as the area of the piece to be graded increases or diminishes in respect to the basic size or area specified, but the size of the defects must not exceed that allowed by the grading rules.

Combinations of Defects

17. When defects or blemishes or combinations thereof, not described in these grading rules are encountered, they will be considered as equivalent to known defects according to their damaging effect upon the piece in the grade under consideration.

Meaning of Equivalent

18. Equivalent means equal, and in construing and applying these rules, the defects allowed, whether specified or not, are understood to be equivalent in damaging effect to those mentioned applying to the stock under consideration.

Imperfections Removed in Dressing

19. Imperfections in rough stock which can be removed in dressing to standard size shall not be considered in determining the grade under these rules.

Defects in Rough and Dressed Stock

20. Defects admissible in rough stock shall be the same as those applying to dressed stock of like kind and grade and, in addition, such other defects as will disappear in dressing such stock to standard sizes shall be allowed.

Vertical Grain

21. Material shall be considered edge grain (vertical grain) when the rings (so-called grain) form an angle of 45 degrees or more with the surface of the piece. When the angle becomes less than 45 degrees at any point, the material shall be known as flat (slash) grain.

Mixed Grades

22. Mixed grades other than the two highest recognized grades for each species, not specifying the proportion of each grade, are not American Lumber Standard grades.

LUMBER SEASONING

23. Specifications dealing with lumber seasoning and moisture content shall be developed by each regional manufacturers' association in accordance with its own conditions and the requirements of the users of its products. Such specifications adopted from time to time by any regional association shall be filed with the Central Committee on Lumber Standards for approval.

SIZE STANDARDS

Basis of Measurement of Sizes

24. Dressed dimensions shall apply to lumber in the condition of seasoning as sold and shipped.

Finished Sizes

25. The thickness and width of finished lumber, S1S or S2S and/or S1E or S2E, shall be in accordance with following tables:

Finish, Common Boards and Strips, Dimension and Heavy Joist

(The thicknesses apply to all widths and the widths to all thicknesses)

Product	*Size, board measure*		*Dressed dimensions*		
	Thickness Inches	*Width Inches*	*Yard Thickness Inches*	*Industrial Thickness Inches*	*Width Inches*
Finish					
		3	5/16		2 5/8
		4	7/16		3 1/2
		5	9/16		4 1/2
		6	11/16		5 1/2
	1	7	25/32	26/32	6 1/2
	1 1/4	8	1 1/16		7 1/4
	1 1/2	9	1 5/16		8 1/4
	1 3/4	10	1 7/16		9 1/4
	2	11	1 5/8	1-6/8	10 1/4
	2 1/2	12	2 1/8		11 1/4
	3		2 5/8		
Common Boards and Strips					
	1	3	25/32	26/32	2 5/8
	1 1/4	4	1 1/16		3 5/8
	1 1/2	5	1 5/16		4 5/8
		6			5 5/8
		7			6 5/8
		8			7 1/2
		9			8 1/2
		10			9 1/2
		11			10 1/2
		12			11 1/2
Dimension and Heavy Joist					
	2	2	1 5/8	1-6/8	1 5/8
	2 1/2	4	2 1/8		3 5/8
	3	6	2 5/8		5 5/8
	4	8	3 5/8		7 1/2
		10			9 1/2
		12			11 1/2

Siding, Flooring, Ceiling, Partition, Shiplap, and Dressed and Matched

26.

(The thicknesses apply to all widths and the widths to all thicknesses except as modified by footnote [1])

Product	*Size, board measure* Thickness Inches	*Size, board measure* Width Inches	*Dressed dimensions* Thickness Inches	*Dressed dimensions* Width Inches
Bevel Siding				
		4	$\frac{7}{16}$ (minimum) x $\frac{3}{16}$	3½
		5	$\frac{10}{16}$ x $\frac{3}{16}$	4½
		6		5½
Wide Bevelled Siding				
		8	$\frac{7}{16}$ (minimum) x $\frac{3}{16}$	7¼
		10	$\frac{9}{16}$ x $\frac{3}{16}$	9¼
		12	$\frac{11}{16}$ x $\frac{3}{16}$	11¼
Rustic and Drop Siding (shiplapped)				
		4	$\frac{9}{16}$	3⅛
		5	¾	4⅛
		6		$5\frac{1}{16}$
		8		6⅞
Rustic and Drop Siding (dressed and matched)				
		4	$\frac{9}{16}$	3¼
		5	¾	4¼
		6	..	$5\frac{3}{16}$
		8	..	7
Flooring				
		2	$\frac{5}{16}$	1½
		3	$\frac{7}{16}$	2⅜
		4	$\frac{9}{16}$	3¼
		5	$\frac{25}{32}$	4¼
	1	6		$5\frac{3}{16}$
	1¼		$1\frac{1}{16}$	
	1½		$1\frac{5}{16}$	
Ceiling				
		3	$\frac{5}{16}$	2⅜
		4	$\frac{7}{16}$	3¼
		5	$\frac{9}{16}$	4¼
		6	$\frac{11}{16}$	$5\frac{3}{16}$
Partition				
		3	¾	2⅜
		4		3¼
		5		4¼
		6		$5\frac{3}{16}$
Shiplap				
	1	4	$\frac{25}{32}$	3⅛
		6		5⅛
		8		7⅛
		10		9⅛
		12		11⅛
Dressed and Matched				
	1	4	$\frac{25}{32}$	3¼
	1¼	6	$1\frac{1}{16}$	5¼
	1½	8	$1\frac{5}{16}$	7¼
		10		9¼
		12		11¼

[1] In tongued and grooved Flooring and in tongued and grooved and shiplapped Ceiling $\frac{5}{16}$", $\frac{7}{16}$", and $\frac{9}{16}$" thick, board measure, the tongue or lap shall be $\frac{3}{16}$ inch wide, with the over-all widths $\frac{3}{16}$ inch wider than the face widths shown above. In all other patterned material, $\frac{11}{16}$", ¾", 1", 1¼", and 1½" thick, board measure, the tongue shall be ¼ inch wide in tongued and grooved lumber, and the lap ⅜ inch wide in shiplapped lumber, with the over-all widths ¼ inch and ⅜ inch wider, respectively, than the face widths shown above.

Factory Flooring, Heavy Roofing, Decking and Sheet Piling

27.

(The thicknesses apply to all widths and the widths to all thicknesses)

Size, board measure		*Dressed dimensions*			
Thickness Inches	*Width Inches*	*Thickness Inches*	*D&M Inches*	*Shiplapped Inches*	*Grooved for splines Inches*
2	4	1⅝	3⅛	3	3½
2½	6	2⅛	5⅛	5	5½
3	8	2⅝	7⅛	7	7½
4	10	3⅝	9⅛	9	9½
	12		11⅛	11	11½

The over-all widths of patterned material 2 inches and thicker, board measure, may be computed on the basis that the tongue shall be ⅜ inch wide in tongued and grooved lumber, and the lap ½ inch wide in shiplapped lumber.

ROUGH DRY SIZES

Thickness Standard Yard Board
Standard Industrial Board

28. The standard rough dry thickness of the standard yard board shall be not less than 29/32 with an allowance of 20 per cent of the shipment, which may be not less than 28/32 inch, and the standard rough dry thickness of the standard industrial board shall be not less than 30/32 inch with an allowance of 10 per cent of the shipment, which may be not less than 29/32 inch.

Thick Boards

29. The standard rough dry thickness of finish, common boards, and dimension of standard sizes 1¼ inches and thicker, board measure, shall not be less than ⅛ inch thicker than the corresponding standard finished dry thickness, with an allowance of 20 per cent of the shipment, which may not be less than 3/32 inch thicker than the corresponding standard finished dry thickness.

Widths

30. The standard width of rough dry finish of 3-inch width, board measure, shall be not more than ¼ inch less than the nominal width, widths 4 to 7 inches, inclusive, board measure, shall be not more than ⅜ inch less than the nominal widths, and widths 8 to 12 inches, inclusive, board measure, shall be not more than ⅝ inch less than the nominal widths, and the rough dry widths of common boards and dimension 7 inches and narrower, shall be not more than ¼ inch less than the nominal widths, and the widths 8 to 12 inches, board measure, shall be not more than ⅜ inch less than the nominal widths.

LENGTHS

Lengths

31. With the exception of the following enumerated odd lengths, no odd lengths are considered standard in yard lumber.

- 2 by 4 inches, 6 and 8 inches—9 and 11 feet.
- 2 by 8 inches, and 10 inches—13 feet.
- 2 by 10 inches—15 feet
- 8 by 8 inches, 10 by 10 inches, 10 by 12 inches, 12 by 12 inches, 14 by 14 inches, 16 by 16 inches, 18 by 18 inches—11 and 13 feet.
- 6 by 16 inches, 6 by 18 inches, 8 by 16 inches, 8 by 18 inches—15 and 17 feet.
- *7 by 16 inches, 9 by 16 inches, 9 by 18 inches—15 and 17 feet.

WORKINGS

Standard Workings

32. The Standard workings of Flooring, Ceiling, Partition, Surfaced Two Sides and Center Matched, Drop Siding, Heavy Flooring, Grooved for Splines, Shiplap, and Byrkit Lath, shall be considered Standard. All other workings shall be considered Special.

End Trimming

33. Unless otherwise stated in the contract of purchase, yard lumber shall be double end-trimmed with a tolerance of not to exceed 3 inches in excess of nominal length.

DESCRIPTION, MEASUREMENT AND TALLY

Tally Standard and Special

34. The thicknesses and widths of lumber as specified in Sections 25, 26, 27, 28, 29 and 30 shall be considered standard. All other sizes shall be considered special.

Description

35. Lumber of standard size shall be described by those standard dimensions.

Thin Lumber

36. Lumber of standard size shall be tallied board measure. On lumber of standard thickness less than 1 inch (board measure), the board-foot measurement shall be based on the surface dimensions.

Tally of Dressed Lumber

37. The board measurement of dressed lumber of standard size shall be based upon the corresponding nominal dimensions of rough green lumber.

Special Size

38. Lumber finished to special size shall be counted (tallied) as of the standard rough size necessarily used in its manufacture.

*Not mentioned in American Lumber Standards, but necessary in railroad use.

Stock Sizes

39. Material shipped on stock sizes shall be tallied by the number of pieces of each size and length in the shipment.

40. In shipments measured on board measure a piece tally in board feet shall be made.

Fractions of Board Foot

41. In material measured with a board rule on actual widths, pieces measuring to the even half foot shall be alternately counted as of the next higher and lower foot count, fractions below the one-half foot shall be dropped, fractions above the one-half foot shall be counted as of the next higher foot.

SHIPPING PROVISIONS

Invoice Dimensions of Non-Standard Lumber

42. The acutal thickness and width of lumber shipped when not of standard size shall be indicated on invoice.

Uneven Sawing

43. In shipments of rough boards and finish, pieces one-half inch or more above the count thickness, such as may be produced by uneven sawing, may, at the option of the buyer, be rejected, or accepted as of the next lower grade.

Average Length

44. The average length of a shipment of lumber shall be computed by dividing the total length in feet by the total number of pieces in a shipment.

Bundling

45. Each length of bundle stock shall be bundled separately..

SHINGLES

Grades

Grades

46. The basic grades of shingles shall be A, B, C, and D. The grade name shall be clearly marked on each and every bundle of wood shingles.

Sizes

Sizes

47. Sixteen-inch 6/2 shingles and 18-inch 5/2 shingles shall be eliminated.

48. Dimension shingles shall be sold full net count, no dimension shingle to be less than ⅛ inch scant of the specified width when dried.

STANDARD GRADES OF RED CEDAR SHINGLES

Random Widths

A

To be strictly clear, edge grain, and free from sap. Random widths.

24" Shingles 4/2"

49. No shingle to be narrower than 4 inches. To be packed 14/14 courses to bunch; 9 bunches to "M"; 4 bunches to "square" 7½ inches exposure, 3 bunches to "square" 10 inches exposure. Bunches must measure 7 inches across butts when green, 6¾ inches when dry.

18" Shingles 5/2¼"

50. No shingle to be narrower than 3 inches. If packed by "M" must count 20/20 courses to bunch, 5 bunches to "M." Bunches must measure 9 inches across butt when green, 8¾ inches when dry. If packed by the "square" must count 18/18 courses to bunch, 4 bunches to square. Bunches must measure 8⅛ inches across butts when green, 7⅞ inches when dry.

16" Shingles 5/2"

51. No shingle to be narrower than 3 inches. If packed by "M" must count 25/25 courses to bunch, 4 bunches to "M." Bunches must measure 10 inches across butts when green, 9¾ inches when dry. If packed by the "square" must count 20/20 courses to bunch, 4 bunches to square, or 5 to "M." Bunches must measure 8 inches across butts when green, 7¾ inches when dry.

B

52. To be strictly clear. Not less than 50 per cent edge grain, with not to exceed ½ inch sap on any portion of the 5 inches measured from the butt, on one edge only.

24" Shingles 4/2"

53. None.

18" Shingles 5/2¼"

54. No shingle to be narrower than 3 inches. If packed by "M" must count 20/20 courses to bunch, 5 bunches to "M." Bunches must measure 9 inches across butts when green, 8¾ inches when dry. If packed by the "square" must count 18/18 courses to bunch, 4 bunches to square. Bunches must measure 8⅛ inches across butts when green, 7⅞ inches when dry.

16" Shingles 5/2"

55. No shingle to be narrower than 3 inches. If packed by "M" must count 25/25 courses to bunch, 4 bunches to "M." Bunches must measure 10 inches across butts when green, 9¾ inches when dry. If packed by "square" must count 20/20 courses to bunch, 4 bunches to square, or 5 to "M." Bunches must measure 8 inches across butts when green, 7¾ inches when dry.

C

56. Ten-inch clear butts and better for 16 and 18-inch shingles and 16-inch clear butts and better for 24-inch shingles not permitted in higher grades. Sap permitted.

24″ Shingles 4/2″

57. No shingle to be narrower than 3 inches. To be packed 14/14 courses to bunch; 9 bunches to "M"; 4 bunches to "square" 7½ inches exposure, 3 bunches to "square" 10 inches exposure. Bunches must measure 6¾ inches across butts when green, 6½ inches when dry.

18″ Shingles 5/2¼″

58. No shingle to be narrower than 2½ inches. If packed by "M" must count 20/20 courses to bunch, 5 bunches to "M." Bunches must measure 8¾ inches across butts when green, 8½ inches when dry. If packed by the "square" must count 18/18 courses to bunch, 4 bunches to square. Bunches must measure 7⅞ inches across butts when green, 7⅝ inches when dry.

16″ Shingles 5/2″

59. No shingle to be narrower than 2½ inches. If packed by "M" must count 25/25 courses to bunch, 4 bunches to "M." Bunches must measure 9¾ inches across butts when green, 9½ inches when dry. If packed by the "square" must count 20/20 courses to bunch, 4 bunches to square, or 5 to "M." Bunches must measure 7¾ inches across butts when green, 7½ inches when dry.

D

60. Six-inch clear butts for 16 and 18-inch shingles, 10-inch clear butts for 24-inch shingles. Sap permitted.

24″ Shingles 4/2″

No shingle to be narrower than 2 inches. Permits shims and feather tips 20 inches long. To be packed 14/14 courses to bunch; 9 bunches to "M"; 4 bunches to "square" 7½ inches exposure, 3 bunches to "square" 10 inches exposure. Bunches must measure 6¾ inches across butts when green, 6½ inches when dry.

18″ Shingles 5/2¼″

61. No shingle to be narrower than 2 inches. Permits shims and feather tips 16 inches long. If packed by "M" must count 20/20 courses to bunch, 5 bunches to "M." Bunches must measure 8¾ inches across butts when green, 8½ inches when dry. If packed by the "square" must count 18/18 courses to bunch, 4 bunches to square. Bunches must measure 7⅞ inches across butts when green, 7⅝ inches when dry.

16″ Shingles 5/2″

62. No shingle to be narrower than 2 inches. Permits shims and feather tips 14 inches long. If packed by "M" must count 25/25 courses to bunch, 4 bunches to "M." Bunches must measure 9½ inches across butts when green, 9¼ inches when dry. If packed by the "square" must count 20/20 courses to bunch, 4 bunches to square, or 5 to "M." Bunches must measure 7½ inches across butts when green, 7¼ inches when dry.

GENERAL RULES

63. All A and B grade shingles must be parallel (a 16 or 18-inch A or B shingle not over ¼ inch off parallel or a 24-inch A shingle not over ⅜ inch off parallel shall be considered parallel), uniform in thickness, and well manufactured. This means shims and feather tips are not permitted; smoothness of faces and butts must be first-class. Badly cross-grained shingles not permitted.

64. No full flat-grain shingle wider than 10 inches permitted in grade B, and no shingle wider than 14 inches permitted in A and B grades; 1 inch over and under in length is permitted in 10 per cent. Shingles cut from equalized blocks may be ¼ inch less than the standard length. C grade admits slight irregularities in thickness. A shingle in C grade, not over ⅜ inch off parallel, shall be considered parallel.

65. When reference is made to edge grain, percentage of edge grain shall be determined by the proportion of actual linear measurement of edge grain to full linear measurement of shingles. In 16 and 18 inch A and B grades not more than 10 per cent of any shipment may be less than 4 inches in width.

66. All shingles to be packed in straight courses in regulation frames 20 inches in width with band sticks not less than 19½ inches long. Openings shall not exceed an average of 1 inch to the course in random width shingles. Discrepancy in inspection in any grade shall not exceed 4 per cent.

67. Color of wood is not a defect in any grade.

SOFTWOOD FACTORY AND SHOP LUMBER

GENERAL PROVISIONS

Grade by Cuttings

68. The grade of factory lumber shall be determined by the percentage of the area of each board or plank available in cuttings of specified or given minimum sizes and qualities, except in the upper grades of shop lumber of all thicknesses.

69. The grade of softwood factory boards or plank or shop lumber shall be determined from the poor face, although the quality of both sides of each cutting must be considered.

70. When lumber is crooked, bowed, cupped or twisted, the cuttings must be so laid out as to be flat and straight along the edges.

Measurement—Fractions

71. Board measurement shall be used in measuring factory lumber. When measured with a board rule, pieces measuring to the even half foot shall be alternately counted as of the next higher and the next lower surface foot; fractions below the half foot shall be dropped, and fractions above the half foot shall be counted as of the next higher foot.

Thicker Than 1"

72. To determine the board foot contents of material thicker than 1 inch the surface measure should be multiplied by the nominal thickness in inches and fractions of an inch.

Based Upon Rough Green

73. The board measurement of dressed factory lumber of standard size shall be based upon the corresponding standard dimension of rough green lumber.

LUMBER SEASONING

74. Specifications dealing with lumber seasoning and moisture content shall be developed by each regional manufacturers' association in accordance with its own conditions and the requirements of the users of its products. Such specifications adopted from time to time by any regional association shall be filed with the Central Committee on Lumber Standards for approval.

SIZES

Basis of Measurement of Sizes

75. Dressed dimensions shall apply to lumber in the condition of seasoning as sold and shipped.

Dressed Thicknesses

Thicknesses

76. The following thicknesses of factory lumber shall be considered standard. All other thicknesses shall be considered special.

Finished thicknesses, S1S or S2S.

Size Board Measure Inches	*Standard Inches*
1	$\frac{26}{32}$
$1\frac{1}{4}$	$1\frac{5}{32}$
$1\frac{1}{2}$	$1\frac{13}{32}$
2	$1\frac{26}{32}$
$2\frac{1}{4}$	$2\frac{1}{8}$
$2\frac{1}{2}$	$2\frac{3}{8}$
3	$2\frac{6}{8}$
4	$3\frac{6}{8}$

Widths

Widths

77. Standard widths shall be five inches and over; factory lumber is usually shipped in random lengths, though specified widths may be shipped. Five-inch widths must be full size in the rough dry condition.

Lengths

Lengths

78. Standard lengths shall be six feet and over in multiples of one foot, except in box lumber which shall be 4 feet and over.

Factory Plank

Door Cuttings

79. In determining the percentage of door cuttings, consideration must be given to the fact that planks are to be ripped full length before cross-cutting, in such manner as will yield the highest grade and largest percentage of door cuttings, except in such cases where planks will yield a higher value by first being cross-cut for rails. In instances where stock is cross-cut for rails and some of the stock so obtained contains stiles or muntins or top rails, which can be obtained by ripping this cross-cut stock, the door cuttings so obtained may be figured in when determining percentages.

GRADE CLASSIFICATIONS FOR SOFTWOOD FACTORY PLANK

80.

FACTORY PLANK Factory lumber graded with reference to its use for doors, sash and other cuttings.	FACTORY CLEARS Upper grades of factory plank containing a high percentage of best quality cuttings.	No. 1 and 2 Clear Factory—Lumber practically clear in wide sizes, to contain not less than 85 per cent of No. 1 door cuttings; not including pieces with over 2 muntins, or muntins only. No. 3 Clear Factory—Lumber containing not less than 70 per cent of No. 1 door cuttings; not including pieces with over 2 muntins, or muntins only.
	SHOP Lower grades of factory plank yielding smaller percentages in smaller and lower quality cuttings.	No. 1 Shop—Lumber of high quality factory grade containing not less than 50 per cent of No. 1 door cuttings; allowing, if necessary, one No. 2 stile in any piece, but no pieces with over two muntins, or muntins only. No. 2 Shop—Lumber containing not less than 25 per cent of No. 1 door cuttings, or 40 per cent of No. 2 door cuttings, or 33⅓ per cent of mixed door cuttings. No. 3 Shop—Lumber of a shop type below the grade of No. 2 Shop and better than box lumber.

QUALITY OF CUTTINGS

Cuttings No. 1 and 2

81. In determining the grades of Factory Plank, two grades of cuttings shall be recognized. These shall be known as No. 1 and No. 2 Cuttings and shall conform to the following rules.

Defects

82. No. 1 Cuttings shall be free from defects on both sides. No restrictions shall be made upon bright sapwood.

83. No. 2 Cuttings shall admit any one of the following defects:

84. Light blue stain on one side, not larger in extent than one-half the area of the side.

85. Medium brown kiln or heart stain covering half the surface on one face, or a greater area of lighter stain, or a proportionate amount on two sides.

86. A small sound and tight knot which does not exceed ⅝ of an inch in diameter.

87. A small pitch pocket not over ⅛ of an inch wide nor over 2 inches long in West Coast woods and not over ⅛ of an inch wide nor over 1 inch long in Idaho White Pine, Pondosa Pine, California White Pine and Sugar Pine.

88. One or more small season checks whose combined length does not exceed 8 inches.

89. Light pitch or small pitch streaks that do not form a pronounced defect.

90. Slightly torn grain on one side.

SIZES OF CUTTINGS

Size of Stiles

91. Stiles shall be 5 inches and 6 inches wide by 6 feet 8 inches to 7 feet 6 inches long. They may be either No. 1 or No. 2 in quality.

Bottom Rails

92. Bottom rails shall be 9 inches and 10 inches wide by 2 feet 4 inches to 3 feet long. They may be either No. 1 or No. 2 in quality.

Muntins

93. Muntins shall be 5 inches and 6 inches wide by 3 feet 6 inches to 4 feet long. They may be either No. 1 or No. 2 in quality.

Top Rails

94. Top rails shall be 5 inches and 6 inches wide by 2 feet 4 inches to 3 feet long. They must be of No. 1 Cutting quality but shall be considered as No. 2 Cuttings.

Sash Cuttings

95. Sash Cuttings shall be 2½ inches and 3½ inches in width by 28 inches and over in length.

Cuttings and Area Use

96. In computing the area of cuttings in each piece of Factory Plank the sizes listed below shall be used. After each cutting size is shown the exact surface area in square feet. For convenience in computing, the

figures shown on the right, representing the area to the nearest ¼ square foot, shall be used.

Size of cutting in board or plank	*Actual Area in Sq. Ft.*	*Nominal Area to be used in application of grading rules*
	Stiles	
5″x6′8″	2.78	3
5″x6′10″	2.85	
5″x7′0″	2.92	
5″x7′2″	2.99	
5″x7′4″	3.06	
5″x7′6″	3.13	
6″x6′8″	3.33	3¼
6″x6′10″	3.42	3½
6″x7′0″	3.50	
6″x7′2″	3.58	3¾
6″x7′4″	3.67	
6″x7′6″	3.75	
	Bottom Rails	
9″x2′4″	1.75	1¾
9″x2′6″	1.875	
9″x2′8″	2.0	2
9″x2′10″	2.125	
9″x3′0″	2.25	2¼
10″x2′4″	1.95	2
10″x2′6″	2.08	
10″x2′8″	2.22	2¼
10″x2′10″	2.36	
10″x3′0″	2.50	2½
	Muntins	
5″x3′6″	1.46	1½
5″x3′8″	1.53	
5″x3′10″	1.60	
5″x4′0″	1.67	1¾
6″x3′6″	1.75	
6″x3′8″	1.83	
6″x3′10″	1.92	2
6″x4′0″	2.0	
	Top Rails	
5″x2′4″	.97	1
5″x2′6″	1.04	
5″x2′8″	1.11	
5″x2′10″	1.18	1¼
5″x3′0″	1.25	
6″x2′4″	1.17	
6″x2′6″	1.25	
6″x2′8″	1.33	
6″x2′10″	1.42	1½
6″x3′0″	1.50	

GRADE CLASSIFICATIONS FOR SOFTWOOD SHOP LUMBER

97.

SHOP LUMBER
Shop Lumber graded for cuttings of minimum and larger sizes or for permissible defects with reference to its use for general cut-up purposes.

- **FOR SHOP LUMBER ONE INCH IN THICKNESS**[1]
  - Select
    Lumber to contain not less than 70% of (a) and/or (b) cuttings.
  - Shop
    Lumber to contain not less than 50% of (a) and/or (b) cuttings.
- **FOR SHOP LUMBER OF ALL THICKNESSES**[2]
  - Tank and Boat Stock—Lumber admitting sound defects that do not impair the usefulness of each piece for the use intended.
  - First and Seconds—Lumber of C Select or Better quality on the reverse side, suitable for remanufacture into products requiring both faces of good quality.
  - Selects—Lumber of C Selects or Better quality on the face side suitable for remanufacture into products requiring one face of good quality.
  - No. 1 Shop—Lumber to contain not less than 60 per cent of (a) and/or (b) cuttings.
  - No. 2 Shop—Lumber to contain not less than 40 per cent of (a) and/or (b) cuttings.
  - Box — Lumber below the grade of No. 2 Shop, to contain not less than 66⅔ per cent sound cuttings not less than 3 inches wide and 18 inches long.

98. In determining the grades of either shop or cut-up lumber based on cuttings, two grades and sizes of cuttings shall be recognized and shall conform to the following rules:

Size of Cuttings

99. (a) Cuttings shall be 9½ inches wide or wider by 18 inches long or longer.

100. (b) Cuttings shall be 5 inches wide or wider by 3 feet long or longer.

Quality of Cuttings

101. (a) Cuttings less than 3 feet long shall be free from all defects on both sides. No restriction need be made upon bright sapwood.

[1] For Northern, Western, and California Pine, and West Coast woods.
[2] For Cypress, Redwood, and North Carolina Pine.

102. (a) Cuttings 3 feet long or longer and (b) cuttings shall have a C Select or Better face in all softwoods except Douglas fir, Sitka spruce and West Coast hemlock, where the face of the cuttings shall be equal to B or Better Finish.

LUMBER INSPECTION PROVISIONS AND SERVICE

Use Shipping Form

103. Lumber must be inspected, accepted or rejected, on grade in the form in which it is shipped. Any subsequent change in manufacture, mill work or dry kilning will prohibit an inspection for the adjustment of claims except with the consent of all parties interested.

Inspection Availability

104. Official lumber association inspection service for the inspecting of lumber sold as of standard size, and standard grade, shall be available to non-members of associations, upon request and at a reasonable charge.

Re-Inspection

105. In case of complaint on account of the grade or tally of any shipment of standard size or standard grade, official lumber association re-inspection shall be available.

Special Grades

106. Official lumber association inspection shall not be required to be furnished for the inspection of "special" grades of lumber (that is, not recognized in published grading rules), and inspection service for "special" grades shall be furnished only when the exact specifications of such grades in writing are furnished to the inspector.

Certificate

107. Where buyers demand, and will pay the cost thereof, a certificate made by a certified lumber association inspector shall be furnished with each shipment so arranged for.

Complaint and Re-inspection

108. Upon receipt of complaint from the purchaser the seller shall immediately request the association under whose rules shipment has been made to provide official re-inspection or re-tally, as the case may be, according to its inspection rules in effect at the time of execution of contract; and the purchaser shall lend all reasonable assistance to facilitate the re-inspection or re-tally.

Expense of Inspections

109. The expense of such re-inspection or re-tally may be divided between the buyer and seller, or may be borne by either, according to agreement between them, but the person calling for the re-inspection shall be responsible to the association for the costs thereof.

110. In case of complaint involving tally, the entire item shall be held intact for re-tally.

Complaint on Grade Only

111. In cases of complaint regarding grade but not involving tally, the buyer is required to accept that portion of a shipment of lumber of standard grade or standard size, which is up to grade or of standard size, as the case may be, holding intact that portion thereof, the grade or size of which is in dispute, for official lumber association inspection; the action on the part of the buyer in accepting and using such portion of the shipment shall not be construed as his acceptance of the entire shipment; further, the buyer shall pay in accordance with the terms of sale for that portion which he accepts, but acceptance by the buyer of a part of a shipment does not prejudice his just claims on account of any unused material that is alleged by him to be below standard grade or not of standard size.

Shipment to be Held Not Exceeding 30 Days

112. The complainant buyer shall hold disputed material intact, properly protected, for not exceeding 30 days after date of the request for official inspection or re-inspection, and shall file complaint with seller within 10 days from receipt of shipment.

Variation of Inspections

113. Each item in a carload or a cargo shall be considered as of the grade invoiced, if, upon official association re-inspection under the grading and inspection rules under which the lumber has been graded and sold, 95 per cent thereof or more is found to be of said grade, the material below said grade to be accepted by the buyer as of its actual grade. Where the de-grades are in excess of 5 per cent of such item or where the de-grades are found upon official re-inspection to be more than one grade lower than the grade invoiced, the de-grades shall be the property of the seller. These provisions shall not apply in the case of specially worked lumber.

Qualified Inspectors

114. All grading shall be done by properly supervised and qualified graders or inspectors.

Contract Clause

115. It is recommended that sales contracts incorporate in substance the following clause:

"Shipment under this contract shall be in accordance with the American Lumber Standards as modified and adopted by the American Railway Engineering Association."

Exemption

116. In case of shipments made or received under such contracts exemption from any provision thereof shall be by special agreement and the burden of proof thereof shall be upon person claiming exemption.

INTRODUCTION TO STRUCTURAL RULES

45. The following rules for Structural Grades conform to the "Basic Provisions for the Selection and Inspection of Softwood Dimension and Timbers where Working Stresses are Required" recommended by the Structural Timber Conference, Chicago, Ill., November 20, 1928, as approved by the Central Committee on Lumber Standards, Chicago, Ill., December 7, 1928.

46. They are complete rules, covering all conditions necessary of consideration in structural grading, and are divided into sections from which combinations are made covering specific purposes and conditions.

47. These specifications may be used for mill orders, selection from or appraisal of stock on hand in either manufacturers', middlemen's or users' stock.

48. The rules cover the following Grades and Use Classifications:

Grades: DENSE SELECT,
Douglas Fir and Southern Pine,
SELECT,
Douglas Fir SELECT,
Other Softwood Species except Southern Pine,
DENSE COMMON,
Douglas Fir and Southern Pine,
COMMON,
All Softwood Species.

Uses: JOIST and PLANK,
Joist, Rafters, Bracing, Scaffold Plank, Factory Flooring, etc.
BEAMS and STRINGERS,
Beams, Girders, Stringers, Bridge Ties, Caps, etc.,
POSTS and TIMBERS,
Posts, Sills, Caps, Timbers, Etc.

Optional Provisions: WANE,
Where Permissible,
SQUARE EDGES,
Where Required or Desired,
HEARTWOOD REQUIREMENT,
For Durability of Untreated Timbers,
SAPWOOD PERMISSIBILITY,
For Material to be Treated.

Sizes of Joist and Plank

Joist, Rafters, Scaffold Plank, Factory Flooring, etc.

Nominal thickness:	2″ to 4″
Nominal widths:	4″ and wider
Standard thickness:	S1S or S2S: ⅜″ off
Standard widths:	4″ to 7″, S1E or S2E: ⅜″ off
	8″ and wider, S1E or S2E: ½″ off.

Sizes of Beams and Stringers

Beams, Girders, Stringers, etc.

Nominal thickness:	5″ and thicker
Nominal widths:	8″ and wider

Sizes of Posts and Timbers

Posts, Caps, Sills, Timbers, etc.

Nominal sizes: 6″ x 6″ and larger

SPECIFICATIONS FOR STRUCTURAL WOOD JOIST, PLANK, BEAMS, STRINGERS, AND POSTS

TIMBER SIZE REQUIREMENTS

Joist and Plank, Surfaced

1A. Structural Joist and Plank shall be when surfaced S1S or S2S not thinner than the nominal dimension less 3/8 inch and when surfaced S1E or S2E not narrower than the nominal width less 3/8 inch for sizes 2 to 7 inches, inclusive, and less 1/2 inch for sizes 8 inches and wider.

Joist and Plank, Rough

1B. Rough Structural Joist and Plank shall be not thinner than the nominal dimension less 1/4 inch, and not narrower than the nominal width less 1/4 inch for sizes 2 to 7 inches, inclusive, and less 3/8 inch for sizes 8 inches and wider.

Beams and Stringers, Posts and Timbers, Surfaced

2A. Structural Beams and Stringers and Posts and Timbers shall be when surfaced S1S, S1E, S2S or S4S not smaller than the nominal size less 3/8 inch for size 7 inches and less, and less 1/2 inch for sizes 8 inches and over.

Beams and Stringers, Posts and Timbers, Rough

2B. Rough Structural Beams and Stringers and Posts and Timbers shall be not smaller than the nominal size less 1/4 inch for sizes 7 inches and less, and less 3/8 inch for sizes 8 inches and over.

Posts and Timbers, Surfaced

3A. Structural Posts and Timbers shall be when surfaced S1S, S1E, S2S or S4S not smaller than the nominal size less 3/8 inch for size 7 inches and less, and less 1/2 inch for sizes 8 inches and over.

Posts and Timbers, Rough

3B. Rough Structural Posts and Timbers shall be not smaller than the nominal size less 1/4 inch for sizes 7 inches and less, and less 3/8 inch for sizes 8 inches and over.

Dressed Dimension Measured Green

4. The dressed dimensions specified in Paragraphs 1A, 2A and 3A shall be minimum dimensions when measured green.

GRADE REQUIREMENTS

Sound Wood

5. This material shall contain only sound wood, free from any form of decay, incipient or advanced, including firm red heart, dote, and rot.

GENERAL

Weight

6a. No pieces of exceptionally light weight shall be permitted in any grade.

Shake, Checks and Splits

b. Shake shall be measured on the ends of a piece. Checks and splits shall be limited as provided for shakes. No checks or combinations of checks with shakes which would reduce the strength to a greater extent than the allowable shake shall be permitted.

Pitch Pockets

c. Pitch pockets are ordinarily not defects in a structural grade. A large number, however, indicates a general lack of bond, and such a piece should be carefully examined for shakes.

Wane and Knots

d. Where wane is permitted there shall be no combination of wane and knots which would reduce the strength more than the maximum allowable knot.

Cluster Knots

e. Cluster knots and knots in groups are not permitted.

Holes

f. Knot holes and holes from other causes than knots shall be permitted as provided for knots.

Knot Measurement

g. The size of a knot shall be measured on the section of the knot appearing on the face under consideration.

Spike Knots

h. Knot sizes specified shall be applied to spike knots as well as to round knots.

Definitions of Faces

i. The faces of a piece of dimension or of a timber are the four longitudinal surfaces of the piece, sometimes further designated as "wide" faces or "narrow" faces.

j. In a piece of dimension or a timber graded for use in bending, wide faces shall be taken as vertical faces, and narrow faces as horizontal faces, unless otherwise noted.

k. When the faces of a piece of dimension or a timber are of equal width, Post and Timber grades shall be used unless otherwise noted. When such a piece of dimension or such a timber is graded for use in bending, the best faces shall be taken as the horizontal faces and should be so marked.

Definition of Edges

l. The edges of a piece of dimension or of a timber are understood to be the narrower faces, and the sides the wider faces. For the locations of knots and other defects the edges of a given face are understood to be the intersection of two adjacent faces, commonly called corners in the past.

KNOTS

Joist and Plank

Wide Faces

7a. On wide faces of Joist and Plank, the size of a knot shall be measured on the mean or average diameter. The mean or average diameter of a knot shall be taken as the average of its maximum and minimum diameter. The average diameter of a spike knot shall be taken as the average of its length and its maximum width.

Narrow Faces

b. On narrow faces of Joist and Plank, the size of a knot shall be taken as its width between lines parallel to the edges of the piece.

Increase to Ends

c. The size of knots on narrow faces and at edges of wide faces of Joist and Plank may increase proportionately from the size allowed in the middle third to twice that size at the ends of the piece.

Increase to Center Line

d. The size of knots on wide faces of Joist and Plank may increase proportionately from the size allowed at the edge to that allowed at the center line.

Beams and Stringers

Wide Faces

8a. On wide or vertical faces of Beams and Stringers the smallest diameter of a knot shall be taken as its size.

Narrow Faces

b. On narrow or horizontal faces of Beams and Stringers the size of a knot shall be taken as its width between lines parallel to the edges of the piece.

Edges of Wide Faces

c. Knots at edges of wide or vertical faces of Beams and Stringers are limited to the same size as on the adjacent narrow or horizontal faces, but the size is measured on the least diameter of the knot instead of on its width between lines parallel to the edges of the timber.

Increase to Ends

d. The size of knots on narrow or horizontal faces and at edges of wide or vertical faces of Beams and Stringers may increase proportionately from the size allowed in the middle third to twice that size at the ends of the piece.

Increase to Center Line

e. The size of knots on wide or vertical faces of Beams and Stringers may increase proportionately from the size allowed at the edge to that allowed at the center line.

POSTS AND TIMBERS

All Faces

9. In Posts and Timbers, the size of a knot shall be measured on the mean or average diameter.

The mean or average diameter of a knot shall be taken as the average of its maximum and minimum diameters. The average diameter of a spike knot shall be taken as the average of its length and its maximum width.

MAXIMUM KNOTS IN DENSE SELECT AND SELECT JOIST AND PLANK

10a. KNOTS ON WIDE FACES

At edges, middle third of length	*Width of face*	*On center line of face*
3/4"	4"	1 1/4"
1"	6"	2"
1 3/8"	8"	2 5/8"
1 3/4"	10"	3 1/4"
2 1/8"	12"	4"
2 3/8"	14"	4 1/4"
2 1/2"	16"	4 5/8"

b. KNOTS ON NARROW FACES OF BOXED HEART PIECES

Thickness of Piece	*Middle Third of Length*
2"	5/8"
3"	1"
4"	1 1/4"

c. The sum of the diameters of all knots within the center half of the length of a Joist or Plank on any face shall not exceed one and one-half times the width of the face on which they occur.

MAXIMUM KNOTS IN DENSE COMMON AND COMMON JOIST AND PLANK

11a. KNOTS ON WIDE FACES

At edges, middle third of length	*Width of Face*	*On center line of face*
1"	4"	1 3/4"
1 1/2"	6"	2 1/2"
2"	8"	3 3/8"
2 1/2"	10"	4 1/4"
3"	12"	5 1/8"
3 1/4"	14"	5 5/8"
3 3/8"	16"	6"

A

b. Knots on Narrow Faces of Boxed Heart Pieces

Thickness of Piece	*Middle Third of Length*
2″	⅞″
3″	1¼″
4″	1¾″

c. The sum of the diameters of all knots within the center half of the length of a Joist or Plank on any face shall not exceed two times the width of the face on which they occur.

Maximum Knots in Dense Select and Select Beams and Stringers

12a.

Narrow or horizontal face, middle third of length	*Width of Face*	*Center line of wide or vertical face*
1¼″	5″	1¼″
1½″	6″	1½″
1¾″	8″	2″
2″	10″	2½″
2⅛″	12″	3″
2¼″	14″	3¼″
2⅜″	16″	3⅜″
...	18″	3⅝″
...	20″	3⅞″
...	22″	4″
...	24″	4¼″

b. The sum of the diameters of all knots within the center half of the length of a Beam or Stringer on any face shall not exceed the width of the face on which they occur.

Maximum Knots in Dense Common and Common Beams and Stringers

13a.

Narrow or horizontal face, middle third of length	*Face Width of*	*Center line of wide or vertical face*
2″	5″	2″
2⅜″	6″	2⅜″
2¾″	8″	3⅛″
3⅛″	10″	4″
3⅜″	12″	4¾″
3⅝″	14″	5⅛″
3⅞″	16″	5½″
...	18″	5⅞″
...	20″	6⅛″
...	22″	6½″
...	24″	6¾″

b. The sum of the diameters of all knots within the center half of the length of a Beam or Stringer on any face shall not exceed one and one-half times the width of the face on which they occur.

Maximum Knots* in Dense Select and Select Posts and Timbers

14a. *Width of Face*	*Knots*
6″	1½″
8″	2″
10″	2½″
12″	3″
14″	3¼″
16″	3⅜″
18″	3⅝″
20″	3⅞″
22″	4″
24″	4¼″

*On faces less than 6″, knots shall not exceed ¼ width of face.

b. The sum of the diameters of all knots in any 6 inches of the length of a Post or Timber shall not exceed twice the size of the maximum knot allowable, nor shall there be two of maximum allowable knots in same 6 inches of length on any one face.

Maximum Knots* in Dense Common and Common Posts and Timbers

15a. *Width of Face*	*Knots*
6″	2⅜″
8″	3⅛″
10″	4″
12″	4¾″
14″	5⅛″
16″	5½″
18″	5⅞″
20″	6⅛″
22″	6½″
24″	6¾″

*On faces less than 6″, knots shall not exceed 4/10 width of face.

b. The sum of the diameters of all knots in any 6 inches of the length of a Post or Timber shall not exceed twice the size of the maximum knot allowable, nor shall there be two of maximum allowable knots in same 6 inches of length on any one face.

SHAKE AND CHECKS

Joist and Plank

Measurement

16. In Joist and Plank the size of a shake shall be taken as the shortest distance between lines inclosing the shake and parallel to the wide faces of the piece.

Beams and Stringers

Measurement

17. In Beams and Stringers the size of a shake shall be taken as the shortest distance between lines inclosing the shake and parallel to the wide faces of the piece.

Posts and Timbers

Measurement

18. In Posts and Timbers the size of a shake shall be measured between lines parallel to each pair of opposite faces, and the greater of these two distances shall be taken as its size.

Maximum Shake and Checks in Dense Select and Select Joist and Plank

19.

Green	*Width of End*	*Seasoned*
½″	2″	⅝″
¾″	3″	1″
1″	4″	1¼″

Maximum Shake and Checks in Dense Common and Common Joist and Plank

20.

Green	*Width of End*	*Seasoned*
¾″	2″	⅞″
1⅛″	3″	1¼″
1½″	4″	1¾″

Maximum Shake and Checks in Dense Select and Select Beams and Stringers

21.

Green	*Width of End*	*Seasoned*
1½″	6″	2″
2″	8″	2⅝″
2½″	10″	3¼″
3″	12″	4″
3½″	14″	4⅝″
4″	16″	5¼″
4½″	18″	6″
5″	20″	6⅝″
5½″	22″	7¼″
6″	24″	8″

Maximum Shake and Checks in Dense Common and Common Beams and Stringers

22.

Green	*Width of End*	*Seasoned*
2″	5″	2⅛″
2⅜″	6″	2⅝″
3⅛″	8″	3½″
4″	10″	4⅜″
4¾″	12″	5¼″
5½″	14″	6⅛″
6⅜″	16″	7″
7⅛″	18″	8″
8″	20″	8⅞″
8¾″	22″	9¾″
9½″	24″	10⅝″

MAXIMUM SHAKE AND CHECKS IN DENSE SELECT AND SELECT POSTS AND TIMBERS

23.

Green	*Width of End*	*Seasoned*
2"	5"	2½"
2⅜"	6"	3"
3⅛"	8"	4"
4"	10"	5"
4¾"	12"	6"
5½"	14"	7"
6⅜"	16"	8"
7⅛"	18"	9"
8"	20"	10"
8¾"	22"	11"
9½"	24"	12"

MAXIMUM SHAKE AND CHECKS IN DENSE COMMON AND COMMON POSTS AND TIMBERS

24.

Green	*Width of End*	*Seasoned*
3"	6"	3½"
4"	8"	4¾"
5"	10"	6"
6"	12"	7⅛"
7"	14"	8⅜"
8"	16"	9½"
9"	18"	10¾"
10"	20"	12"
11"	22"	13⅛"
12"	24"	14⅜"

SLOPE OF GRAIN

ALL CLASSIFICATIONS

Measurement

25. Slope of Grain shall be measured over a distance which will assure the determination of the general slope of the grain, not influenced by short, local deviations.

In Bending

26. In a piece in bending, it is of greatest importance on the top and bottom faces. If meeting the limitation of a grade in these locations, it may be somewhat greater elsewhere.

DENSE SELECT AND SELECT JOIST AND PLANK

27. Slope of grain in center half of length shall not exceed 1 in 12.

DENSE COMMON AND COMMON JOIST AND PLANK

28. Slope of grain in center half of length shall not exceed 1 in 10.

Dense Select and Select Beams and Stringers

29. Slope of grain in center half of length shall not exceed 1 in 15.

Dense Common and Common Beams and Stringers

30. Slope of grain in center half of length shall not exceed 1 in 10.

Dense Select and Select Posts and Timbers

31. Slope of grain shall not exceed 1 in 10.

Dense Common and Common Posts and Timbers

32. Slope of grain shall not exceed 1 in 8.

WANE OR SQUARE EDGES

Dense Select and Select Grade

Wane 1/8

33A. Wane is permitted, not exceeding 1/8 the width of any face.

Square Edges

Square

33B. All edges must be square.

Dense Common and Common Grade

Wane 1/4

34A. Wane is permitted, not exceeding 1/4 the width of any face.

Square Edges

Square

34B. All edges must be square.

HEARTWOOD AND SAPWOOD

Durability Untreated

Heartwood requirements to be specified as required from following:

Heartwood Provisions

Joist and Plank

35. Joist and Plank shall have not less than 85 per cent heart on the two faces, measured across the faces anywhere in the length of the piece.

Beams and Stringers

36. Beams and Stringers shall have not less than 85 per cent heart on each of the four faces, measured across the faces anywhere in the length of the piece.

Timbers 85 Per Cent

37A. These timbers shall have not less than 85 per cent heart on each of the four faces, measured across the face anywhere in the length of the piece.

Timbers, One Face All Heart, Others 85 Per Cent

37B. These timbers shall have all heart on one narrow face, the other narrow face and the two sides shall have not less than 85 per cent of heart, measured across the face or sides anywhere in the length of the piece.

Timbers, One Face All Heart, Others 75 Per Cent

37C. These timbers shall have all heart on one narrow face, the other narrow face and the two sides shall have not less than 75 per cent of heart, measured across the face or sides anywhere in the length of the piece.

For Treatment

Provision for sapwood for timber to be treated is covered by following:

Sapwood

Sapwood Not Restricted

38. There is no restriction as to sapwood for this material.

RATE OF GROWTH AND DENSITY

Close Grain

Douglas Fir of Select grade is to be selected for close grain.

Density

Southern Pine or Douglas Fir of Dense Select grade is to be selected for density.

Close Grained Douglas Fir

Close Grain

39. Douglas Fir shall be of close grain, averaging on either one end or the other not less than six nor more than twenty annual rings per inch measured over a three-inch portion of a radial line located as described below. Pieces averaging from five to six annual rings per inch shall be accepted as the equivalent of close grain if having one-third or more summerwood.

Dense Douglas Fir

Dense

40. Douglas Fir shall be dense, averaging on either one end or the other not less than six annual rings per inch and, in addition, one-third or more summerwood measured over a three-inch portion of a radial line located as described below. The contrast in color between summerwood and springwood shall be distinct. Coarse grained material excluded by this rule shall be accepted as dense if averaging one-half or more summerwood.

Close Grain or Density

Radial Line Representative

41. The radial line shall be representative of the average growth on the cross-section. When the radial line specified is not representative, it shall be shifted sufficiently to present a fair average, but the distance from the pith to the beginning of the three-inch portion of the line in boxed heart pieces shall not be changed.

Close Grain

Average on Two Radial Lines

42. In case of disagreement, two radial lines shall be chosen, and the number of rings shall be the average determined on these lines.

Density

Average on Two Radial Lines

43. In case of disagreement, two radial lines shall be chosen, and the number of rings and summerwood shall be the average determined on these lines.

Location of Radial Line in Douglas Fir

Sidecut Pieces

44a. In side cut pieces of Douglas Fir, the radial line shall be at a right angle to the annual rings and the center of the three-inch portion of the line shall be at the center of the end of the piece.

Boxed Heart Pieces

b. In boxed heart pieces the line shall run from the pith to the corner farthest from the pith. When the least dimension is six inches or less, the three-inch portion of the line shall begin at a distance of one inch from the pith. When the least dimension is more than six inches, the three-inch portion of the line shall begin at a distance from the pith equal to two inches less than one-half the least dimension of the piece.

c. If a three-inch portion of the radial line cannot be obtained, the measurement shall be made over as much of the three-inch portion as is available.

Dense Southern Pine

Dense

45. Southern Pine shall be dense, averaging on either one end or the other not less than six annual rings per inch and, in addition, one-third or more summerwood measured over a three-inch portion of a radial line located as described below. The contrast in color between summerwood and springwood shall be sharp and the summerwood shall be dark in color, except in pieces having considerably above the minimum requirement for summerwood. Coarse grained material excluded by this rule shall be accepted as dense if averaging one-half or more summerwood.

Radial Line Representation

46. The radial line shall be representative of the average growth on the cross-section.

Average on Two Radial Lines

47. In case of disagreement, two radial lines shall be chosen, and the number of rings and summerwood shall be the average determined on these lines.

Location of Radial Line in Southern Pine

Boxed Heart Pieces

48a. In boxed heart pieces of Southern Pine, the measurement shall be made over the third, fourth and fifth inches from the pith along the radial line.

Pith Not Present

b. In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the inspection shall be made over three inches on an approximate radial line beginning at the edge nearest the pith in timbers over three inches in thickness and on the second inch nearest to the pith in timbers three inches or less in thickness.

Pith Present, But Less Than Five-Inch Radial Line

c. In material containing the pith but not a five-inch radial line, which is less than two inches by eight inches in section or less than eight inches in width, that does not show over sixteen square inches on the cross-section, the inspection shall apply to the second inch from the pith. In larger material that does not show a five-inch radial line, the inspection shall apply to the three inches farthest from the pith.

Douglas Fir or Southern Pine

Inspection for Density

49. In inspection for density, reasonable variation of opinion between inspectors must be recognized. In reinspection of a particular lot of timbers for density, for every three timbers accepted as having one-third or more summerwood, one of the remaining timbers shall be accepted if agreed upon as having between 30 and 33⅓ per cent summerwood.

NOTES ON WORKING STRESSES FOR STRUCTURAL GRADES OF AMERICAN LUMBER STANDARDS

1. Many factors enter into the determination of working stresses. It is practically impossible to make a sufficient number of tests on large specimens of each species, containing the various defects of the species and in their various combinations, to determine working stresses in this way. It has been found, however, that similar defects have practically the same effect in all species.

2. Working stresses are based on the strength of green, clear wood, increase in strength through drying being largely offset by development of defects during the drying, and are varied for conditions of exposure in properties affected by this factor.

3. It is not sufficient, though, to apply an arbitrary factor of safety to test results on small clear pieces in all species in order to determine nominal working stresses for the clear wood of large sizes, to which defect-effect factors can be applied to determine working stresses for grades containing defects, nor to apply factors of safety to average values alone, but

consideration must be given to minimum strengths as well as average, to the tendency of a species to run characteristically high or low in grade, to effect of length of time under load on the species, to effect of character of loading, and to conditions of exposure and susceptibility to them.

4. These factors and characteristics sometimes dictate quite a variation in the relative status of species, as to whether small clear sizes are the basis for comparison, or structural sizes. One species may run characteristically lower than another in small, clear values, while running characteristically higher in strength in structural sizes of equivalent character.

5. Determination of basic clear grade values for reduction to working stresses for grades containing defects, therefore, involves consideration of many factors in the light of experience and judgment, rather than the arbitrary application of factors of safety to test results on small clear pieces.

6. It is on this basis that the working stresses recommended by the Forest Products Laboratory, U.S. Forest Service, for structural grades complying with Basic Provisions for Structural Material of American Lumber Standards have been determined, and they can be depended on to assure that the low line piece of a grade will sustain safely the working stresses of the grade. In Beam and Stringer, and Post and Timber grades, stresses are given only for the species commonly cut to those sizes. Stresses for other species can be obtained from the Forest Products Laboratory, Madison, Wisconsin.

7. Properties for which working stresses are required are: Extreme fiber in bending, horizontal shear, compression parallel to grain, compression perpendicular to grain, and modulus of elasticity.

8. In some of these properties, working stresses are governed by conditions of exposure; in other properties they are not. In some properties, working stresses are affected by grade, as fixed by limitation on size and location of knots, extent of shake and checks, and extent of slope of grain. In dimension sizes, continuously dry, higher stresses are allowed in extreme fiber in bending than are recommended for larger sizes with equal defects. In Douglas fir and southern pine, working stresses in some properties are increased for requirement of percentage of summerwood, and in Douglas fir, for limitation on rate of growth.

9. Working stresses for extreme fiber in bending are varied with extent of exposure, with size and position of knots, with slope of grain, and with size of piece; in horizontal shear, they are varied with extent of shake and checks; in compression parallel to grain, with exposure, and with size and location of knots, and slope of grain; in compression perpendicular to grain, with exposure.

10. Working stresses in horizontal shear are not varied with extent of exposure, nor with size of piece; in compression parallel to grain they are not varied with size; in compression perpendicular to grain, they are not varied with grade or size; in modulus of elasticity, they are taken as the same under all conditions.

11. In Douglas fir and southern pine, working stresses in extreme fiber

in bending, horizontal shear, compression parallel to grain and compression perpendicular to grain, may be increased 1/6 for dense material, over material not so selected. Values in Douglas fir may be increased 1/15 for close grain in extreme fiber in bending, compression parallel to grain and compression perpendicular to grain. Values in horizontal shear are not increased for close grain. Modulus of elasticity is not varied with density or rate of growth.

Variations in Working Stresses

12.

Property	*Governing Defects*	*Conditions of Exposure*	*Grade*	*Size of Piece*	*Rate of Growth*	*Density*
Extreme Fiber in Bending	Knots and Slope of Grain	x	x	x*	x	x
Horizontal Shear	Shake and Checks	–	x	–	–	x
Compression Parallel	Knots and Slope of Grain	x	x	–	x	x
Compression Perpendicular		x	–	–	x	x
Modulus of Elasticity		–	–	–	–	–

*Dry location only.
xVaries with.
–Does not vary with.

13. In dimension sizes four inches and less in thickness, the development of defects during seasoning does not offset the increase in strength from drying as much as in larger sizes, and in these sizes used in dry locations, working stresses in extreme fiber in bending are increased proportionately from equal values with timbers, and dimension not continuously dry, in a grade having 50 per cent of the strength of clear wood, to values 25 per cent greater in clear wood.

Minimum Strength Value

14. Structural grades are developed to assure minimum strength values. The defects permitted in the Common grades provide material having not less than 60 per cent of the strength of green clear wood, and in the Select Structural grades, of 75 per cent, although in Douglas fir the stresses recommended in compression and in extreme fiber in bending are 80 per cent of green clear wood strength on account of provision of close grain.

Exposure

15. Working values are given for three conditions of exposure during use: (a) Continuously dry, (b) Occasionally wet but quickly dried, (c) More or less continuously damp or wet. Judgment should be exercised as to the conditions of exposure which should be assumed in a particular case.

Continuously Dry

(a) Continuously dry contemplates use in interior or protected construction not subject to conditions of excessive dampness or high humidity.

Occasionally Wet

(b) Occasionally wet but quickly dried assumes use in such exterior structures as bridges, trestles, grandstands or bleachers, and exposed frame work of open sheds.

Usually Wet

(c) More or less continuously damp or wet would apply to material exposed to waves or tidewater, or in contact with earth, or used in a building in portions that would be more or less continuously wet.

Impact

16. Working values may be used without allowance for impact up to impact of 100 per cent of loads figured. The ability of timbers to support loads is very dependent on the duration of the stress. Tests have demonstrated that the load required to break timbers in several years is about $\frac{9}{16}$ of that required to break them as in ordinary laboratory tests. When the time is shortened still further, as in impact loading, the load required to break a timber is correspondingly increased. Approximately, this increase is 10 per cent, when the time is reduced to 1/10 of the previous time.

Maximum Horizontal Shear

17. Working values for horizontal shear are maximum values. The maximum unit horizontal shear at any point in a beam is 3/2 of the average unit shear obtained by dividing the total shear at that point by the area of the cross section. To get the total safe shearing stress at any cross section, the area of the cross section should be multiplied by 2/3 the maximum allowable horizontal shear. To obtain the required area to carry any given shear, the total shear should be divided by 2/3 the maximum allowable unit shear.

Analysis for Shear Stress

18. Recognition of all loads in designing for loads concentrated near a support, or for moving loads, gives a calculated shearing stress higher than is actually developed.

19. For concentrated loading, in calculating the shear at one end of a beam, the loads between that end and the nearer quarter point, or between that end and a point distant three times the depth of the beam from it, whichever would be the lesser distance from the support, may be considered as acting at that point.

20. For moving loads, as on highway bridges or railway stringers, in computing the shear at one end it is safe to ignore the wheel loads between that end and the nearer quarter point, or between that end and a point three times the depth of the beam or stringer from it, whichever would be the lesser distance from the support, when the balance of the span is assumed to be loaded so as to give a maximum shear stress.

Shear Stresses for Joint Details

21. Shear stresses for joint details may be taken as 50 per cent greater than the values for horizontal shear given in the table.

Permanent Set

22. Timber constantly yields under continued loading, acquiring a permanent set. This set with a fully loaded beam is about equal to the deflection using the modulus of elasticity as given in the tables. In order to minimize the results of sag, it is advisable to use values one-half those given in the tables.

Compression in Short Columns

23. The working stresses for compression parallel to grain are for use on posts, struts, etc., with unsupported length not greater than ten times their least dimension. They are also for use in end bearing on compression members, as a short column or strut is more likely to fail at the end than at any other point in its length, and the variations in moisture content are greater at that point.

Compression in Medium Length Columns

24. For columns of intermediate length, the Forest Products Laboratory finds that a fourth-power parabola, tangent to the Euler curve, is a conservative representation of the law controlling the strength. That is, from the short block to the long column in which the strength is dependent on stiffness, there is a falling off in ultimate strength which follows a smooth curve, very flat at first but curving sharply to become tangent to the Euler curve at two-thirds of the ultimate crushing strength.

Formula

25. For columns from $\frac{P}{A} = S$ to $\frac{P}{A} = \frac{2}{3}S$

$$\frac{P}{A} = S\left[1 - \frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$$

where P = Total load in pounds.
A = Area in square inches.
$\frac{P}{A}$ = Unit compressive stress.
S = Safe stress in compression parallel to grain for short columns.
l = Unsupported length in inches.
d = Least dimension in inches.
E = Modulus of elasticity.
K = The $\frac{l}{d}$ at the point of tangency of the parabolic and Euler curves, at which $\frac{P}{A} = \frac{2}{3}S$. The value of K for any species and grade is $\frac{\pi}{2} \cdot \sqrt{\frac{E}{6S}}$

Influence of Defects

26. The influence of defects on the compressive strength of columns of constant cross section decreases as the length increases. When $\frac{l}{d}$ equals the value of K for the species and grade, defects such as are allowable in the grade have little influence on the strength as a column. Beyond this length the investigation of the strength of columns by the Laboratory indicated that the Euler formula is quite accurate for long wood columns with pin-end connections and that the maximum load is dependent upon stiffness. In such columns, a factor of safety of 3 should be applied to values of modulus of elasticity in order to obtain safe loading.

27. The Laboratory does not, with the present data and under ordinary conditions, find justification for increasing the stresses on square-end columns over those for carefully centered pin-end columns. Tests to determine the influence of end conditions are still being made and it is probable that under special conditions higher stresses can be used.

Long Columns

28. For long columns, including factor of safety of 3 =

$$\frac{P}{A}=\frac{\pi^2}{36}\frac{E}{\left(\frac{l}{d}\right)^2}$$

Maximum Length

29. Columns should be limited in slenderness to $\frac{l}{d}=50$.

30. Post and Timber grades may be applied to material smaller than 6″ by 6″ by limiting the size of knots to the proportion of width of face permitted on a 6″ face.

Direct Tension

31. For direct tension the same values as for extreme fiber stress in bending may be used. Straight grained wood has greater resistance to tension than to any other kind of stress. It has been found, however, practically impossible to design joints that will develop anywhere near the full tensile strength.

Joists and Beams in Direct Tension

32. Grades of Joists or Beams may be used for members in direct tension, as in bottom chords of trusses, increase in size of defects towards ends being permissible because of the gradual application of stresses through splice plates or end connections.

Joist and Plank—Vertical or Horizontal

33. The provisions of the Joist and Plank grades are such that material graded on them may be used on edge as joist or rafters, or flat, as scaffold

plank or factory flooring and working stresses for these grades may be applied to such material used with wide faces either vertical or horizontal. Joist and Plank grades apply to material not thicker than four inches. Material thicker than four inches, for use in bending, should be graded on Beam and Stringer grades. In such material with loads applied to the wide face, the knot limitations for this face are those for the narrow face as given in the rules.

Working Stresses in Timbers Nearly Square

34. Material to be used for such purposes as caps, bridge ties, etc., where strength in bending is a factor, should be specified in Beam and Stringer grades, although of shape more commonly considered as of timber grades, as the method of measuring knots in Post and Timber grades makes it impracticable to assign bending stresses to them. Caps and bridge ties are often square or have horizontal faces wider than the vertical faces, in contrast to Beam and Stringers, in which the narrow faces are horizontal faces and the wide faces are vertical, and care should be exercised that knot limitations are applied to the proper faces.

35. In material subject to varying bending moments, such as full-length sills of wood under-framed cars, it should be specified that defects throughout the length be limited as in the center third of Beams and Stringers.

Two-Span Stringers

36. In railway stringers of two span length, it should be specified that defects throughout the center two-thirds be limited as in the center third of a single span stringer, for the maximum moment will be over the center support and although the full positive moment would not be developed in either as long as there was resistance to negative moment over the center support, there might be circumstances in which full positive moment of resistance at the centers of the two spans would be desirable.

37. The strength of timbers and posts in round form is greater than would be expected from the ordinary engineering formulas. The strength, stiffness and shearing value of round timbers of any species may be assumed to be identical with that of square timbers of the same grade and cross-sectional area. Tapered timbers should be assumed as of uniform diameter, the point of measurement being one-third the span from the small end, but the diameter should not be assumed to be more than one and one-half times the end diameter.

38. The strength of round columns may be considered the same as that of square columns of the same cross-sectional area. In long tapered columns the strength may be assumed as identical with that of a square column of the same length, and of cross-sectional area equal to that of the round timber measured at a point one-third its length from the small end. The stress at the small end must not exceed the allowable stress for short columns.

39. Detailed studies on the strength of timber in round form are available in Reports 180 and 181 of the National Advisory Committee for

Aeronautics on "The Influence of the Form of a Wooden Beam on Its Stiffness and Strength."

FACTORS OF SAFETY

Elastic Limit and Breaking Strength

40. In determining working stresses, the Forest Products Laboratory has considered both elastic limit and breaking strength. Elastic limit, however, is more variable and less definite than ultimate strength, and the latter is taken as the more dependable basis for the determination of safe working stresses.

Factor of Safety

41. The factor of safety at a given working stress varies materially with the duration of the stress. At the recommended working stresses, the average timber in buildings has a factor of safety of 6 on impact loadings,* 4 under five-minute loads and 2¼ under long-time loading, with a minimum factor of safety of 2 on 75 per cent of the pieces under long-time loading, while about one piece in 100, of very light weight and with maximum defects for the grade, would be expected to break at 1½ times the recommended stress under loading of approximately 10 years duration. The factor of safety on new timbers in bridge work is about ½ greater than the above values.

*If impact stresses are neglected when less than 100 per cent of the live load producing them, the factor of safety for such loads would be reduced from 6 to a minimum of 3.

WORKING STRESSES

Pounds per Square Inch

For Grades Complying with Basic Provisions for Structural Grades of American Lumber Standards

JOIST AND PLANK AND BEAMS AND STRINGERS

Continuously Dry

Select Grade

Species	*Extreme Fiber in Bending*	*Compression Perpendicular to Grain*	*Maximum Horizontal Shear*	*Modulus of Elasticity*
Cedar, western red	900	200	80	1,000,000
northern and southern white	750	175	70	800,000
Port Orford	1100	250	90	1,200,000
Alaska	1100	250	90	1,200,000
Cypress, southern	1300	350	100	1,200,000
Douglas fir, Coast Region	1600	345	90	1,600,000
dense	1750	380	105	1,600,000
Rocky Mountain Region	1100	275	85	1,200,000
Fir, balsam	900	150	70	1,000,000
golden, noble, silver, white	1100	300	70	1,100,000
Hemlock, West Coast	1300	300	75	1,400,000
eastern	1100	300	70	1,100,000
Larch, western	1200	325	100	1,300,000
Pine, southern, dense	1750	380	128	1,600,000
California, Idaho and Northern white, Pondosa and sugar	900	250	85	1,000,000
Norway	1100	300	85	1,200,000
Redwood	1200	250	70	1,200,000
Spruce, red, white, Sitka	1100	250	85	1,200,000
Englemann	750	175	70	800,000
Tamarack, eastern	1200	300	95	1,300,000

Common Grade

Species	*Extreme Fiber in Bending*	*Compression Perpendicular to Grain*	*Maximum Horizontal Shear*	*Modulus of Elasticity*
Cedar, western red	720	200	64	1,000,000
northern and southern white	600	175	56	800,000
Port Orford	880	250	72	1,200,000
Alaska	880	250	72	1,200,000
Cypress, southern	1040	350	80	1,200,000
Douglas fir, Coast Region	1200	325	72	1,600,000
dense	1400	380	84	1,600,000
Rocky Mountain Région	880	275	68	1,200,000
Fir, balsam	720	150	56	1,000,000
golden, noble, silver, white	880	300	56	1,100,000
Hemlock, West Coast	1040	300	60	1,400,000
eastern	880	300	56	1,100,000
Larch, western	960	325	80	1,300,000
Pine, southern	1200	325	88	1,600,000
dense	1400	380	103	1,600,000
California, Idaho and northern white, Pondosa and sugar	720	250	68	1,000,000
Norway	880	300	68	1,200,000
Redwood	960	250	56	1,200,000
Spruce, red, white, Sitka	880	250	68	1,200,000
Englemann	600	175	56	800,000
Tamarack, eastern	960	300	76	1,300,000

Note.—Values are those recommended by Forest Products Laboratory.

WORKING STRESSES

Pounds per Square Inch

For Grades Complying with Basic Provisions for Structural Grades of American Lumber Standards

JOIST AND PLANK AND BEAMS AND STRINGERS

Occasionally Wet But Quickly Dried

Select Grade

Species	Extreme Fiber in Bending 4" and Thinner	Extreme Fiber in Bending 5" and Thicker	Compression Perpendicular to Grain	Maximum Horizontal Shear	Modulus of Elasticity
Cedar, western red	710	800	150	80	1,000,000
northern and southern white	580	....	140	70	800,000
Port Orford	890	1000	200	90	1,200,000
Alaska	890	....	200	90	1,200,000
Cypress, southern	980	....	250	100	1,200,000
Douglas fir, Coast Region	1240	1385	240	90	1,600,000
Dense	1370	1515	265	105	1,600,000
Rocky Mtn. Region	800	900	225	85	1,200,000
Fir, balsam	670	....	125	70	1,000,000
golden, noble, silver, white	800	....	225	70	1,100,000
Hemlock, West Coast	980	1100	225	75	1,400,000
eastern	800	....	225	70	1,100,000
Larch, western	980	1100	225	100	1,300,000
Pine, southern, dense	1370	1515	265	128	1,600,000
California, Idaho and northern white, Pondosa and sugar	710	....	150	85	1,000,000
Norway	890	....	175	85	1,200,000
Redwood	890	1000	150	70	1,200,000
Spruce, red, white, Sitka	800	900	150	85	1,200,000
Englemann	580	....	140	70	800,000
Tamarack, eastern	980	....	225	95	1,300,000

Common Grade

Species	Extreme Fiber in Bending 4" and Thinner	Extreme Fiber in Bending 5" and Thicker	Compression Perpendicular to Grain	Maximum Horizontal Shear	Modulus of Elasticity
Cedar, western red	600	640	150	64	1,000,000
northern and southern white	490	....	140	56	800,000
Port Orford	760	800	200	72	1,200,000
Alaska	760	....	200	72	1,200,000
Cypress, southern	830	....	250	80	1,200,000
Douglas fir, Coast Region	980	1040	225	72	1,600,000
Dense	1145	1210	265	84	1,600,000
Rocky Mtn. Region	680	720	225	68	1,200,000
Fir, balsam	570	....	125	56	1,000,000
golden, noble, silver, white	680	....	225	56	1,100,000
Hemlock, West Coast	830	880	225	60	1,400,000
eastern	680	....	225	56	1,100,000
Larch, western	830	880	225	80	1,300,000
Pine, southern	980	1040	225	88	1,600,000
dense	1145	1210	265	103	1,600,000
California, Idaho and northern white, Pondosa and sugar	600	....	150	68	1,000,000
Norway	760	....	175	68	1,200,000
Redwood	760	800	150	56	1,200,000
Spruce, red, white Sitka	680	720	150	68	1,200,000
Englemann	490	....	140	56	800,000
Tamarack, eastern	830	....	225	76	1,300,000

Note.—Values are those recommended by Forest Products Laboratory.

WORKING STRESSES

Pounds per Square Inch

FOR GRADES COMPLYING WITH BASIC PROVISIONS FOR STRUCTURAL GRADES OF AMERICAN LUMBER STANDARDS

JOIST AND PLANK AND BEAMS AND STRINGERS

MORE OR LESS CONTINUOUSLY DAMP OR WET

SELECT GRADE

Species	Extreme Fiber in Bending: 4" and Thinner	Extreme Fiber in Bending: 5" and Thicker	Compression Perpendicular to Grain	Maximum Horizontal Shear	Modulus of Elasticity
Cedar, western red	670	750	125	80	1,000,000
northern and southern white	530	....	100	70	800,000
Port Orford	800	900	150	90	1,200,000
Alaska	800	....	150	90	1,200,000
Cypress, southern	800	....	225	100	1,200,000
Douglas fir, Coast Region	950	1065	215	90	1,600,000
dense	1050	1165	235	105	1,600,000
Rocky Mtn. Region	620	700	200	85	1,200,000
Fir, balsam	530	....	100	70	1,000,000
golden, noble, silver, white	710	....	200	70	1,100,000
Hemlock, West Coast	800	900	200	75	1,400,000
eastern	710	....	200	70	1,100,000
Larch, Western	800	900	200	100	1,300,000
Pine, southern, dense	1050	1165	235	128	1,600,000
California, Idaho and northern white, Pondosa and sugar	670	....	125	85	1,000,000
Norway	710	....	150	85	1,200,000
Redwood	710	800	125	70	1,200,000
Spruce, red, white, Sitka	710	800	125	85	1,200,000
Englemann	440	....	100	70	800,000
Tamarack, eastern	800	....	200	95	1,300,000

COMMON GRADE

Species	Extreme Fiber in Bending: 4" and Thinner	Extreme Fiber in Bending: 5" and Thicker	Compression Perpendicular to Grain	Maximum Horizontal Shear	Modulus of Elasticity
Cedar, western red	570	600	125	64	1,000,000
northern and southern white	450	....	100	56	800,000
Port Orford	680	720	150	72	1,200,000
Alaska	680	....	150	72	1,200,000
Cypress, southern	680	....	225	80	1,200,000
Douglas fir, Coast Region	750	800	200	72	1,600,000
dense	875	930	235	84	1,600,000
Rocky Mtn. Region	530	560	200	68	1,200,000
Fir, balsam	450	....	100	56	1,000,000
golden, noble, silver, white	600	....	200	56	1,100,000
Hemlock, West Coast	680	720	200	60	1,400,000
eastern	600	....	200	56	1,100,000
Larch, western	680	720	200	80	1,300,000
Pine, southern	750	800	200	88	1,600,000
dense	875	930	235	103	1,600,000
California, Idaho and northern white, Pondosa and sugar	570	....	125	68	1,000,000
Norway	600	....	150	68	1,200,000
Redwood	600	640	125	56	1,200,000
Spruce, red, white, Sitka	600	640	125	68	1,200,000
Englemann	370	....	100	56	800,000
Tamarack, eastern	680	....	200	76	1,300,000

NOTE.—Values are those recommended by Forest Products Laboratory.

SAFE LOADS FOR WOODEN COLUMNS

1. The unit working stresses in compression parallel to grain for columns whose ratio of unsupported length to least dimension does not exceed 10 shall be not greater than that given for the species in the accompanying table of Working Stresses.

2. For columns the ratio of whose unsupported length to least dimension is greater than 10, the following formula shall be used until the reduction in allowable stress equals one-third the stress for short columns:

$$\frac{P}{A} = S\left[1 - \frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$$

where P = Total load in pounds.
A = Area in square inches.
$\frac{P}{A}$ = Unit compressive stress.
S = Safe stress in compression parallel to grain for short columns.
l = Unsupported length in inches.
d = Least dimension in inches.
E = Modulus of elasticity.
K = The $\frac{l}{d}$ at the point of tangency of the parabolic and Euler curves, at which $\frac{P}{A} = \frac{2}{3}S$.
The value of K for any species and grade is

$$\frac{\pi}{2}\sqrt{\frac{E}{6S}}$$

3. For columns of greater length the Euler formula below, which includes factor of safety of 3 shall be used:

$$\frac{P}{A} = \frac{\pi^2}{36}\,\frac{E}{\left(\frac{l}{d}\right)^2}$$

4. Columns shall be limited in slenderness to $\frac{l}{d} = 50$.

Values of "K" for Columns of Intermediate Length

Species	Continuously Dry Select	Continuously Dry Common	Occasionally Wet Select	Occasionally Wet Common	Usually Wet Select	Usually Wet Common
edar, western red	24.2	27.1	24.2	27.1	25.1	28.1
" Port Orford	23.4	26.2	24.6	27.4	25.6	28.7
ouglas Fir,						
Coast region: Select	23.7	27.3	24.9	28.6	27.0	31.1
Dense Select	22.6	24.9	23.8	26.1	25.8	28.3
Rocky Mountain region	24.8	27.8	24.8	27.8	26.5	29.7
emlock, West Coast	25.3	28.3	25.3	28.3	26.8	30.0
arch, western	22.0	24.6	23.1	25.8	25.8	28.8
ak, red and white	24.8	27.8	26.1	29.3	27.7	31.1
ine, southern: Select	23.7	27.3	24.9	28.6	27.0	31.1
Dense Select	22.6	24.9	23.8	26.1	25.8	28.3
edwood	22.2	24.8	23.4	26.1	25.6	28.6
pruce, red, white, Sitka	24.8	27.8	25.6	28.7	27.5	30.8

Strength of Columns of Intermediate Length
In Per Cent of Strength of Short Columns

Values for the expression $\left[1-\frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$

in the Formula: $\frac{P}{A}=S\left[1-\frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$

$\text{PERCENTAGE}=\left[1-\frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$

K \ $\frac{l}{d}$	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
22	97	96	95	93	91	88	85	81	77	72	67									
23	98	97	95	94	92	90	87	84	81	77	72	67								
24	98	97	96	95	93	92	89	87	84	80	76	72	67							
25	98	98	97	96	94	93	91	89	86	83	80	76	72	67						
26	99	98	97	96	95	93	92	91	89	86	83	80	76	72	67					
27	99	98	98	97	96	95	93	92	90	88	85	82	79	74	71	67				
28	99	98	98	97	96	95	94	93	91	89	87	85	82	79	75	71	67			
29	99	99	98	98	97	96	95	94	92	91	89	87	84	82	79	75	71	67		
30	99	99	98	98	97	97	96	95	94	92	90	88	86	84	81	78	75	71	67	
31	99	99	99	98	98	97	96	95	94	93	92	90	88	86	84	81	78	75	71	67

Ratio of Length to Least Dimension in Rectangular Timbers.

This table can also be used for columns not rectangular, the l/d being quivalent to .289 l/r, where r is the least radius of gyration of the section.

WORKING STRESSES

Pounds per Square Inch

For Grades Complying with Basic Provisions for Structural Grades of American Lumber Standards

POSTS AND TIMBERS 6"x6" AND LARGER

Continuously Dry

Species	*Compression Parallel to Grain — Ratio of Length to Least Dimension (L/D)* 10	12	14	16	18	20	25	30	35	40	50	*Modulus of Elasticity*
Select Grade												
Cedar, western red	700	686	674	656	629	592	438	304	224	171	110	1,000,000
Douglas fir, Coast Region	1175	1149	1127	1093	1045	975	702	487	358	274	175	1,600,000
Dense	1285	1251	1222	1176	1112	1022	702	487	358	274	175	1,600,000
Rocky Mountain Region	800	786	774	753	726	688	526	365	268	206	132	1,200,000
Hemlock, West Coast	900	885	872	852	823	783	614	426	313	240	153	1,400,000
Larch, western	1100	1068	1041	999	937	851	570	396	291	223	142	1,300,000
Pine, southern, dense	1285	1251	1222	1176	1112	1022	702	487	358	274	175	1,600,000
Redwood	1000	972	947	910	856	781	526	365	268	206	132	1,200,000
Spruce, red, white, Sitka	800	786	774	753	726	688	526	365	268	206	132	1,200,000
Common Grade												
Cedar, western red	560	553	547	538	524	505	425	304	224	171	110	1,000,000
Douglas fir, Coast region	880	870	861	847	826	796	675	487	358	274	175	1,600,000
Dense	1025	1017	996	965	935	893	698	487	358	274	175	1,600,000
Rocky Mtn. Region	640	632	627	617	602	582	500	365	268	206	132	1,200,000
Hemlock, West Coast	720	712	706	696	680	660	573	426	313	240	153	1,400,000
Larch, western	880	863	849	828	798	752	570	396	291	223	142	1,300,000
Pine, southern	880	870	861	847	826	796	675	487	358	274	175	1,600,000
Dense	1025	1017	996	965	935	893	698	487	358	274	175	1,600,000
Redwood	800	786	773	754	726	688	526	365	268	206	132	1,200,000
Spruce, red, white, Sitka	640	632	627	617	602	582	500	365	268	206	132	1,200,000

Note.—Values are those recommended by Forest Products Laboratory.

WORKING STRESSES

Pounds per Square Inch

For Grades Complying with Basic Provisions for Structural Grades of American Lumber Standards

POSTS AND TIMBERS 6"x6" AND LARGER

Occasionally Wet But Quickly Dried

Species	*Compression Parallel to Grain — Ratio of Length to Least Dimension (L/D)* 10	12	14	16	18	20	25	30	35	40	50	*Modulus of Elasticity*
Select Grade												
Cedar, western red	700	686	673	654	628	591	438	304	224	171	110	1,000,000
Douglas fir, Coast Region	1065	1045	1028	1003	968	915	702	487	358	274	175	1,600,000
Dense	1165	1139	1118	1083	1036	971	702	487	358	274	175	1,600,000
Rocky Mountain Region	800	785	772	753	728	688	526	365	268	206	132	1,200,000
Hemlock, West Coast	900	885	871	851	824	783	612	426	313	240	153	1,400,000
Larch, western	1000	976	955	922	877	810	570	396	291	223	142	1,300,000
Pine, southern, dense	1165	1139	1118	1083	1036	971	702	487	358	274	175	1,600,000
Redwood	900	879	861	834	794	738	526	365	268	206	132	1,200,000
Spruce, red, white, Sitka	750	738	728	712	690	657	525	365	268	206	132	1,200,000
Common Grade												
Cedar, western red	560	552	546	537	523	504	425	304	224	171	110	1,000,000
Douglas fir, Coast region	800	792	784	773	758	736	644	487	358	274	175	1,600,000
Dense	935	924	905	886	858	830	681	487	358	274	175	1,600,000
Rocky Mtn. region	640	632	625	616	602	582	502	365	268	206	132	1,200,000
Hemlock, West Coast	720	712	705	695	681	659	572	426	313	240	153	1,400,000
Larch, western	800	787	777	760	736	704	564	396	291	223	142	1,300,000
Pine, southern	800	792	784	773	758	736	644	487	358	274	175	1,600,000
Dense	935	924	905	886	858	830	681	487	358	274	175	1,600,000
Redwood	720	709	700	685	666	637	518	365	268	206	132	1,200,000
Spruce, red, white, Sitka	600	594	588	580	568	552	485	365	268	206	132	1,200,000

WORKING STRESSES

Pounds per Square Inch

For Grades Complying with Basic Provisions for Structural Grades of American Lumber Standards

POSTS AND TIMBERS 6"x6" AND LARGER

More or Less Continuously Damp or Wet

Species	*Compression Parallel to Grain — Ratio of Length to Least Dimension (L/D)* 10	12	14	16	18	20	25	30	35	40	50	*Modulus of Elasticity*
Select Grade												
Cedar, western red	650	638	629	614	594	565	437	304	224	171	110	1,000,000
Douglas fir, Coast Region	905	893	883	867	846	814	683	487	358	274	175	1,600,000
Dense	990	974	961	940	910	871	698	487	358	274	175	1,600,000
Rocky Mountain Region	700	690	681	669	651	623	514	365	268	206	132	1,200,000
Hemlock, West Coast	800	789	780	766	745	717	600	426	313	240	153	1,400,000
Larch, western	800	787	776	760	736	704	565	396	291	223	142	1,300,000
Pine, southern, dense	990	974	961	940	910	871	698	487	358	274	175	1,600,000
Redwood	750	737	727	712	690	657	525	365	268	206	132	1,200,000
Spruce, red, white, Sitka	650	642	635	625	611	589	500	365	268	206	132	1,200,000
Common Grade												
Cedar, western red	520	514	509	502	491	475	413	304	224	171	110	1,000,000
Douglas fir, Coast region	680	675	670	664	655	641	588	482	358	274	175	1,600,000
Dense	795	785	777	767	753	730	642	482	358	274	175	1,600,000
Rocky Mtn. region	560	554	551	544	535	521	465	365	268	206	132	1,200,000
Hemlock, West Coast	640	634	629	622	612	598	537	426	313	240	153	1,400,000
Larch, western	640	633	627	618	606	588	519	396	291	223	142	1,300,000
Pine, southern	680	675	670	664	655	641	588	482	358	274	175	1,600,000
Dense	795	785	777	767	753	730	642	482	358	274	175	1,600,000
Redwood	600	594	588	580	568	552	483	365	268	206	132	1,200,000
Spruce, red, white, Sitka	520	515	512	507	500	489	446	365	268	206	132	1,200,000

Note.—Values are those recommended by Forest Products Laboratory.

Appendix B

(2) CONTINUE WORK ON SIMPLIFICATION OF GRADING RULES AND CLASSIFICATION OF TIMBER FOR RAILWAY USES, COLLABORATING WITH OTHER ORGANIZATIONS DEALING WITH THIS SUBJECT

C. J. Hogue, Chairman, Sub-Committee; H. Austill, W. E. Hawley, J. B. Maddock, J. A. Newlin, D. W. Smith.

In the work on this subject given to the Sub-Committee, the collaboration with the lumber industry in its program of standardization has been carried on by members of the Committee in continuation of the program which has been going ahead since 1922 under the leadership of President Hoover, then Secretary of Commerce.

By means of the General Lumber Conference in Washington on May 3d, meetings of the Special Structural Timber Committee on November 20th and the Consulting Committee on Lumber Standards on November 22d and the Central Committee on Lumber Standards on December 7, 1928, in Chicago, the lumber industry through its conference of manufacturers, distributors and consumers has practically completed the program for the standardization of the Softwood Lumber and Timber industry.

The industry plans to continue the machinery set up for the purpose of revision of standards and also in hope that progress in the hardwood industry will permit of the setting up of standards for this material. The Committee desires the continued assignment of this subject.

The representatives of this Committee working in harmony with the representatives of the American Society for Testing Materials and in harmony with the representatives of the other branches of the lumber industry have participated in this program throughout the six years. Revisions of previous conclusions have been introduced by others and accepted by the Committee, striving to secure the greatest adherence to a unified set of standards.

The Committee has brought in its report each year revisions which were to put into effect these standards.

The problem before the industry now is that of education and the securing the maximum use of these standards in place of the older forms.

The revisions for standards of practice, size and quality have been shown in Appendix A, reported by the Sub-Committee on Revision of the Manual.

Material which had been previously accepted for printing in the Manual has been revised by this Committee and because of its nature and a desire to reduce this section in the Manual, the subject-matter of this revision is noted for withdrawal from the Manual and for publication only in the Proceedings. Additional data on determination and calculation of working stresses has been included. This material appears below.

STRUCTURAL GRADES OF LUMBER AND TIMBER AND THE METHOD OF THEIR DERIVATION

Purpose

1. The purpose of structural grades is to offer means for selecting structural material for strength, and for assured minimum strength, in order that appropriate working stresses may be assigned for its use.

Factors of Strength

2. The most important factors which influence the strength of structural material are the size, number and location of defects, and the extent of exposure to moisture during use. These factors must all be considered in design or grading if the maximum utilization is to be obtained from the material used.

Structural Grades and Strength

3. Structural grades control defects by limiting their size and location in accordance with their effect upon strength. Working stresses for each species are recommended by the Forest Products Laboratory, United States Forest Service, and take into consideration the allowable defects, the moisture content as determined by conditions of use, and, in the case of southern pine and Douglas fir, rate of growth and percentage of summerwood.

Moisture

4. Moisture affects the strength of structural members both directly and indirectly. The direct effect of loss of moisture is the stiffening and strengthening of the wood fibers. This increase in strength, however, is accompanied by checking, splitting, warping and twisting—as a consequence, some of the strength due to drying is lost. The strength of green wood is, therefore, used as the basis of working stresses.

Size Effects

5. In dimension sizes, four inches and less in thickness, the development of defects during seasoning does not offset the increase in strength from drying as much as in larger sizes, and in these sizes used in dry locations, higher working stresses in extreme fiber in bending can be permitted with the same sized defects as in pieces of larger size, or greater defects can be permitted with the same working stresses.

Conditions of Exposure

6. During use, construction material is subject to varying conditions of moisture, from the dry location of a heated building to the continually wet condition of some pier and dock timbers. These conditions must be taken into account in recommending working stresses.

Defects

7. The principal defects which must be limited in structural grades are: Knots, Shakes and Checks, and Slope of Grain.

Influence of Knots

8. The influence of a knot in a beam is determined by its location, and the area of its projection on the cross-section of the piece, the method of measurement being such as to give the best approximation of this influence.

9. Knots in posts and large beams are likely to show on one face only or to run diagonally through the piece and reduce strength in practically direct proportion to their size as measured.

10. In dimension sizes the knot is likely to run directly through the piece; and the strength when used on edge, as affected by a knot on a wide face, is measured by the square of the effective depth of the piece, assuming the knot in its worst position, near the edge of the piece. The reduction in strength due to the knot is approximately twice the ratio of the size of the knot to the width of the face.

11. On narrow faces of boxed heart pieces, and on center lines of wide faces, of dimension sizes used on edge, as joist, and on wide faces of such material used, flat, as plank, the influence of a knot is directly proportional to its size, as in posts and large beams. Attention need not be given to knots on narrow faces of side cut joist and plank—pieces not containing the pith—as such knots will also show on wide faces, and their limitation there is sufficient. In boxed heart piece—pieces containing the pith—a knot may show only on a narrow face, and its limitation there is necessary.

Location of Knots—Joist and Plank

12. Knot limitations on edges of wide faces of dimension sizes, for use as joist, are more severe than would be required for use flat, as plank, the sizes applying along the center lines of the wide faces as joist being those which could theoretically apply at any point across the width if used only as plank. It has been found, however, that under practically all conditions of use, knots along the edges of planks are more objectionable than knots along the center lines, and this is recognized in some commercial yard grades of plank in a stricter limitation of knots along the edges of wide faces than along the center lines. The same knot limitations are applied, therefore, to material to be used either as joist or plank, and the same working stresses are assigned for use either on edge or flat.

Increase in Size of Knots

13. In both joist and beams, knots reduce strength most along the top and bottom edges, through the center portion. The sizes of knots permitted in various portions of a joist or beam are limited in accordance with the stresses, and are allowed to increase toward the ends and toward the centerlines of the vertical faces. Sizes on narrow faces and at edges of wide faces may increase uniformly, outside the middle third, to sizes twice as great at the ends of a piece; they may increase uniformly from edges of wide faces to center lines of wide faces; and on center lines of wide faces, when smaller than sizes allowed at ends of a piece at edges, may increase uniformly to those sizes, outside the middle third.

Small and Large Knots

14. There is greater proportional distortion of grain around a large knot than around a smaller one and, consequently, shrinkage in seasoning causes greater internal stresses, so knot sizes are increased proportionately to width of faces only up to 6-inch top and bottom faces of beams, 12-inch vertical faces of beams and 12-inch faces of dimension and posts. Beyond these widths of face, increase is proportional to the square root of the ratio of the wider faces to these widths.

Sum of Diameters of Knots

15. The distribution and sum of the diameters of knots are of importance, as well as the maximum size of a single knot.

16. The sum of the diameters of all knots in the center half of the length of any face of a Beam or Stringer is limited, in direct proportion of increase, from no knots in clear wood to a sum of diameters of twice the width of the face in a grade having 50 per cent of the strength of clear wood.

17. In Joist and Plank, in dry locations, the sum of the diameters of knots in the center half of the length of any face may be greater by one-half the width of the face than the sum of the diameters permitted in Beams and Stringers.

18. In Posts and Columns, the sum of the diameters of all knots in any 6 inches of length, in any grade, is limited to twice the size of the maximum knot allowable.

Knots in Joist and Plank

19. In joist and plank, the mean or average diameter of a knot is taken as its size. In such thin and relatively wide material, whether used on edge or flat, this is a safe measure of the influence of knots on strength, and has the commercial advantage of being directly applicable to yard grades of lumber. This method of measurement will exclude damaging spike knots, and can be applied to them as well as to round or oval knots.

Knots in Beams

20. On the top or bottom of a beam, the influence of knots is measured largely by the surface fibers cut. The projection of a knot on a line at a right angle to the edge is, therefore, used.

21. On the vertical faces of a beam, the depth to which a knot penetrates is of great importance, while the influence of the number of surface fibers cut, and the amount of grain distortion, is considerably less important than on the horizontal faces. The smallest diameter of the knot is, therefore, used. One of the best examples illustrating the reason for the smallest diameter being taken on the vertical face is the splitting of a boxed heart timber into two pieces. The long spike knots which might be opened up in this way would be no more injurious to the strength of the two pieces than they would as a single knot in a boxed heart piece, and the two pieces so cut would be less subject to seasoning checks than a boxed heart piece

Knots in Columns

22. In columns there are two factors: (a) area of cross-section occupied by knot, which would probably be measured best by the small diameter of the knot; and (b) the influence of bending stresses when the column begins to fail, probably measured best by the projection of the knot. In short columns, the area of the cross-section is of primary importance; as the column gets longer, the factor of bending strength increases in importance until the condition of the Euler formula is reached, when stiffness, on which knots have practically no influence, becomes the ruling factor. The average diameter, therefore, is used as that which applies best to the average condition.

Knots and Holes

23. In grades for structural uses no distinction is made between intergrown knots and encased knots or knotholes, observation at the Forest Products Laboratory having shown that intergrown knots reduce strength fully as much as encased knots or knotholes.

Shakes and Checks

24. Shakes reduce the area of a beam acting in resistance to shear, and the limitations placed on shake in such material are based on this reduction. Checks are limited on the same basis as shakes, and no combination of shakes and checks is permitted which would reduce strength to a greater extent than would the allowable size of either separately. Shake in green material is assumed to reduce shearing stress in direct proportion to its extent. A greater amount of shake is permitted in seasoned material, made up for by the increased resistance of the remaining cross-section when seasoned.

Shakes in Joist and Beams

25. In Joist and Plank, and Beams and Stringers, shake in green material is permitted in direct proportion of increase from none in a grade of the strength of green, clear wood to ½ the width of the piece in a grade having one-half the strength of green, clear wood. In seasoned material, shake is similarly permitted from 1/9 the width of the piece in a grade of the strength of green, clear wood to 5/9 the width of the piece in a grade having one-half the strength of green, clear wood.

26. Shake and Checks in Dense Select and Select Joist and Plank shall not exceed when green ¼ width of end nor when seasoned ⅓ width of end.

Shake and Checks in Dense Common and Common Joist and Plank shall not exceed when green 4/10 width of end nor when seasoned 4/9 width of end.

Shake and Checks in Dense Select and Select Beams and Stringers shall not exceed when green ¼ width of end nor when seasoned ⅓ width of end.

Shake and Checks in Dense Common and Common Beams and Stringers shall not exceed when green 4/10 width of end nor when seasoned 4/9 width of end.

Shakes in Posts and Columns

27. Shakes and checks, as a rule, have little influence on the strength of columns, unless so extensive as to split a column practically in two. Limitation on shakes and checks in columns is more important from the standpoints of appearance, and of reducing opportunity for decay. In post and timber grades, shake in green material is permitted in direct proportion of increase 2/10 the width of the piece in a grade of the strength of green, clear wood to 6/10 the width of the piece in a grade having one-half the strength of green, clear wood. In seasoned material, shake is similarly permitted from 3/10 the width of the piece in a grade having the strength of green, clear wood to 7/10 the width of the piece in a grade having one-half the strength of green, clear wood.

28. Shake and Checks in Dense Select and Select Posts and Timbers shall not exceed when green 4/10 width of end nor when seasoned ½ width of end.

Shake and Checks in Dense Common and Common Posts and Timbers shall not exceed when green ½ width of end nor when seasoned 6/10 width of end.

Slope of Grain

29. Slope of grain, resulting either from diagonal sawing or from spiral or twisted grain in the log, is limited in accordance with the recommendations of the Forest Products Laboratory, based on the results of detailed study of the effect of cross and spiral grain upon strength, and the weakening of material by checks which invariably develop and, without exception, follow the grain.

Dimension Sizes and Beams

30. There is not much reduction in strength from cross grain in a piece of dimension or in a beam until an angle of 1 in 40 is reached. From that slope in a joist or beam of a grade having the strength of green, clear wood, slope of grain is limited to 1 in 20 in a grade having seven-eighths this strength, to 1 in 15 in a grade of three-fourths, 1 in 11 in a grade of five-eighths, and 1 in 8 in a grade of one-half the strength of green, clear wood.

Posts and Columns

31. In a post or column the influence on strength of cross grain and of the checks following the grain is much less than in a piece in bending, but excessive cross or spiral grain is objectionable on account of the twisting and diagonal checks which occur in seasoning. Slope of grain in a post or column is limited to 1 in 20 in a grade having the strength of green, clear wood, 1 in 15 in a grade of seven-eighths this strength, of 1 in 11 in a grade of three-fourths, 1 in 8 in a grade of five-eighths, and 1 in 6 in a grade having one-half the strength of green, clear wood.

Measurement

32. Slope of grain should be measured over a distance which will assure the determination of the general slope of the grain not influenced by short, local deviations. In a piece in bending, it is of greatest importance on the top and bottom faces. If meeting the limitation of a grade in these locations, it may be somewhat greater elsewhere.

Wane and Knots

33. Wane is limited by such considerations as bearing area, nailing edge, appearance, etc., rather than by effect on strength. The percentage reduction in strength resulting from wane toward the center of a beam is about double the percentage reduction in cross-sectional area. No combination of wane and knots is permitted which would reduce the strength more than the maximum allowable knot. The occurrence of maximum wane and maximum knot in the same cross-section at the center of a beam would be so rare, however, and the effect of allowable maximum wane is so small a percentage of the effect of maximum allowable knot, that the additional reduction in strength beyond the effect of the knot would be slight and it is usually unnecessary to give attention to combination of wane and knots.

Pitch Pockets

34. Pitch pockets are ordinarily not defects in a structural grade. A large number, however, indicates a general lack of bond, and such a piece should be carefully examined for shakes.

Heartwood and Sapwood

35. Heartwood and sapwood have been found by the Forest Products Laboratory to be of equal strength, and no requirement of heartwood need be made when strength alone is the governing factor. Heart requirement, when durability of untreated material under exposure is a factor, as in bridges, trestles, docks and piers, or in damp buildings, or buildings in which conditions of high humidity prevail, may be specified in any grade, according to exposure and use.

No Restriction on Sapwood

36. When preservative treatment is to be applied, there should be no restriction as to sapwood, as sapwood is easier to treat than heartwood and a large amount is to be preferred.

Density and Strength

37. The density of the wood substance of all species is practically the same. The dry weight is, therefore, a measure of the amount of wood substance present; and on the amount of wood substance present depends the strength of the clear wood. No pieces of exceptionally light weight are permitted in any grade, but pieces considered too light for a particular grade, but of that grade otherwise, may in general, be accepted in a lower grade.

Density and Summerwood

38. In southern pine and Douglas fir, the proportion of summerwood,

the dark portion of the annual ring, furnishes a practical means of estimating density. Selection of these species for density assures material of the highest character from the standpoint of strength, and uniformity in strength, in the clear wood.

Contrast Between Summerwood and Springwood

39. In acceptance for density the contrast in color between summerwood and springwood should be distinct. Absence of contrast occasionally occurs in bands of growth rings which appear on the whole darker in color than the adjacent material. The summerwood merges into the springwood abnormally with a gradual change of color, leaving practically no material which has the normal appearance of springwood. Such material has been called by a number of names, including proud-wood, red-wood, and compression-wood. It has a decided end shrinkage, is weak in tension, and material of this character in even a small part of a cross-section is undesirable in high-class structural timbers.

Rate of Growth and Strength

40. Selection of Douglas fir for close grain is an assurance of increased strength—not as great as selection for percentage of summerwood, but for many purposes selection for close grain, i. e., not less than six nor more than twenty annual rings per inch, will assure material of suitable type.

Minimum Requirements and Maximum Defects

41. Structural grades specify minimum requirements and maximum defects, all of which may be present at one time. Relative density, however, compensates to some extent for any defect or a combination of defects. When, therefore, a particular piece is slightly below the provisions of a grade in some or all defects, but is of average density or above, or is slightly low in density but is above the provision of the grade in other respects, the relative effect on properties concerned should be given consideration, as regards fiber stress in bending, compression parallel to grain and horizontal shear.

Re-inspection

42. In inspection for density, reasonable variation of opinion between inspectors should be recognized. A fair provision for re-inspection of a particular lot of timbers for density would be that for every three timbers accepted as having one-third or more summerwood, one of the remaining timbers be accepted if agreed upon as having between 30 and 33⅓ per cent summerwood .

DETERMINATION AND CALCULATION OF WORKING STRESSES

Relation of Strength of Dry Dimension to Timbers, and to Dimension Not Dry

1. In dimension sizes four inches and less in thickness, used in locations continuously dry, working stresses in extreme fiber in bending are

increased proportionately from equal values with timbers, and dimension not continuously dry, in a grade having 50 per cent of the strength of clear wood, to values 25 per cent greater in clear wood.

2. The relation between extreme fiber stresses in dimension continuously dry and dimension not continuously dry is shown by the following equations in terms of ratio of strength and ratio of defects of dimension not continuously dry, the strength of clear wood of dimension not continuously dry being taken as 100 per cent:

$$D = S + \left(\frac{S - .50}{.50}\right)\frac{CS}{4}$$

$$D = S + \frac{S - .50}{2} \qquad (1)$$

$$D = \frac{3}{2}S - .25$$

$$\frac{3}{2}S = D + .25$$

$$S = \frac{2}{3}\left(D + .25\right) \qquad (2)$$

D = ratio of extreme fiber stress in dry dimension to extreme fiber stress of green, clear wood.

S = ratio of extreme fiber stress in equivalent grades of timbers, or dimension not dry, to extreme fiber stress of green, clear wood.

CS = extreme fiber stress of green clear wood = 100 per cent.

Joist and Plank and Beams and Stringers of American Lumber Standards

3. SELECT GRADES: Basis, 75 per cent of strength of clear wood in properties affected by grade.

(a) Extreme fiber in bending, 75 per cent of clear wood stress for condition of exposure.
Douglas fir, increased 1/15 for close grain.
Dense Douglas fir and southern pine, increased 1/6 for density.

(b) Compression perpendicular to grain, same as clear wood for condition of exposure.
Douglas fir, increased 1/15 for close grain.
Dense Douglas fir and southern pine, increased 1/6 for density.

(c) Horizontal shear, 75 per cent of clear wood stress.
Dense Douglas fir and southern pine, increased 1/6 for density.

(d) Modulus of elasticity, same as clear wood.

A

4. Common Grades: Basis, 60 per cent of strength of clear wood in properties affected by grade.

(a) Extreme fiber in bending, 60 per cent of clear wood stress for condition of exposure.
Dense Douglas fir and southern pine, increased 1/6 for density.

(b) Compression perpendicular to grain, same as clear wood for condition of exposure.
Dense Douglas fir and southern pine, increased 1/6 for density.

(c) Horizontal shear, 60 per cent of clear wood stress.
Dense Douglas fir and southern pine, increased 1/6 for density.

(d) Modulus of elasticity, same as clear wood.

5. Joist and Plank, Continuously Dry: These grades, although having larger proportional defects than Beam and Stringer grades, have the same working stresses because of being dimension sizes, continuously dry.

$$\text{Ratio for defects} = \frac{2}{3}(D + .25)$$

$$\text{Select grade} = \frac{2}{3}(.75 + .25)$$

Select grade = 66⅔ per cent grade for defects.

$$\text{Common grade} = \frac{2}{3}(.60 + .25)$$

Common grade = 56⅔ per cent grade for defects.

6. Joist and Plank, Occasionally Wet, and Usually Wet: These grades, having larger proportional defects than Beam and Stringer grades, have stresses proportional to their grade-defect values in properties affected by grade, not being used under conditions continually dry.

Select grade = 66⅔ per cent of strength of clear wood.
Common grade = 56⅔ per cent of strength of clear wood.

Posts and Timbers of American Lumber Standards

7. Select Grades:

(a) Compression parallel to grain, 75 per cent of clear wood stress for condition of exposure.
Douglas fir, increased 1/15 for close grain.
Dense Douglas fir and southern pine, increased 1/6 for density.

(b) Modulus of elasticity, same as clear wood.

8. Common Grades:

(a) Compression parallel to grain, 60 per cent of clear wood stress for condition of exposure.
Dense Douglas fir and southern pine, increased 1/6 for density.

(b) Modulus of elasticity, same as clear wood.

Basic Working Stresses for Clear Wood of Structural Sizes

To which grade-strength ratios can be applied to determine working stresses for grades containing defects. Stresses in extreme fiber in bending, compression parallel to grain, and compression perpendicular to grain are varied with extent of exposure. Stresses in horizontal shear and modulus of elasticity are not varied with exposure.

Species	Continuously Dry			Occasionally Wet but Quickly Dried			More or Less Continuously Damp or Wet			All Conditions of Exposure	
	Extreme Fiber in Bending	Compression Perpendicular to Grain	Compression Parallel to Grain L/D=10	Extreme Fiber in Bending	Compression Perpendicular to Grain	Compression Parallel to Grain L/D=10	Extreme Fiber in Bending	Compression Perpendicular to Grain	Compression Parallel to Grain L/D=10	Maximum Horizontal Shear	Modulus of Elasticity
Cedar, Alaska	1466	250		1333	200		1200	150		120	1,200,000
Cedar, northern and southern white	1000	175		866	140		800	100		93	800,000
Cedar, Port Orford	1466	250		1333	200		1200	150		120	1,200,000
Cedar, western red	1200	200	933	1066	150	933	1000	125	866	106	1,000,000
Cypress, southern	1733	350		1466	250		1200	225		133	1,200,000
Douglas fir, Coast type	2000	325	1466	1733	225	1333	1333	200	1133	120	1,600,000
Close-grained	2133	345	1565	1850	240	1420	1420	215	1210	120	1,600,000
Dense	2333	380	1711	2020	265	1555	1555	235	1320	140	1,600,000
Douglas fir, Rocky Mt. type	1466	275	1066	1200	225	1066	933	200	933	113	1,200,000
Fir, balsam	1200	150		1000	125		800	100		93	1,000 000
Fir, commercial white	1466	300		1200	225		1066	200		93	1,100,000
Hemlock, eastern	1466	300		1200	225		1066	200		93	1,100,000
Hemlock, West Coast	1733	300	1200	1466	225	1200	1200	200	1066	100	1,400,000
Larch, western	1600	325	1466	1466	225	1333	1200	200	1066	133	1,300,000
Pine, California, Idaho and northern white, Pondosa, and sugar	1200	250		1066	150		1000	125		113	1,000,000
Pine, Norway	1466	300		1333	175		1066	150		113	1,200,000
Pine, southern yellow	2000	325	1466	1733	225	1333	1333	200	1133	146	1,600,000
Dense	2333	380	1711	2020	265	1555	1555	235	1320	171	1,600,000
Redwood	1600	250	1333	1333	150	1200	1066	125	1000	93	1,200,000
Spruce, Engelmann	1000	175		866	140		666	100		93	800,000
Spruce, red, white, and Sitka	1466	250	1066	1200	150	1000	1066	125	866	113	1,200,000
Tamarack	1600	300		1466	225		1200	200		126	1,300,000

BASIS FOR CHARTS SHOWING RELATION OF DEFECTS TO STRENGTH

Formulas for Effect of Knots

1. DIMENSION:

   (a) Knots on narrow faces.
   (b) Knots on edges of wide faces.
   (c) Knots on center lines of wide faces.
   } (1. Green) (2. Dry)

2. BEAMS:

   (a) Knots on narrow or horizontal faces, and at edges of wide or vertical faces.
   (b) Knots on center lines of wide or vertical faces.

3. POSTS:

   (a) Knots on all faces, but governed by narrow faces of posts not square.

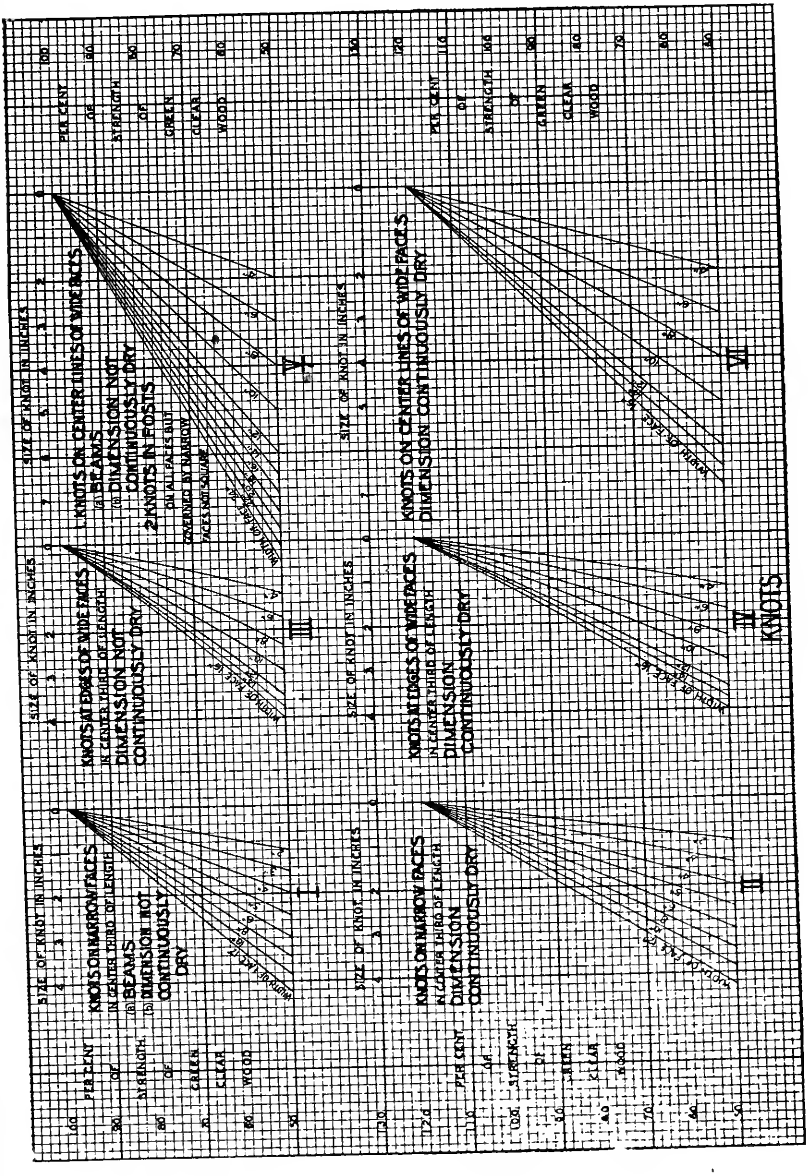
NOTATION

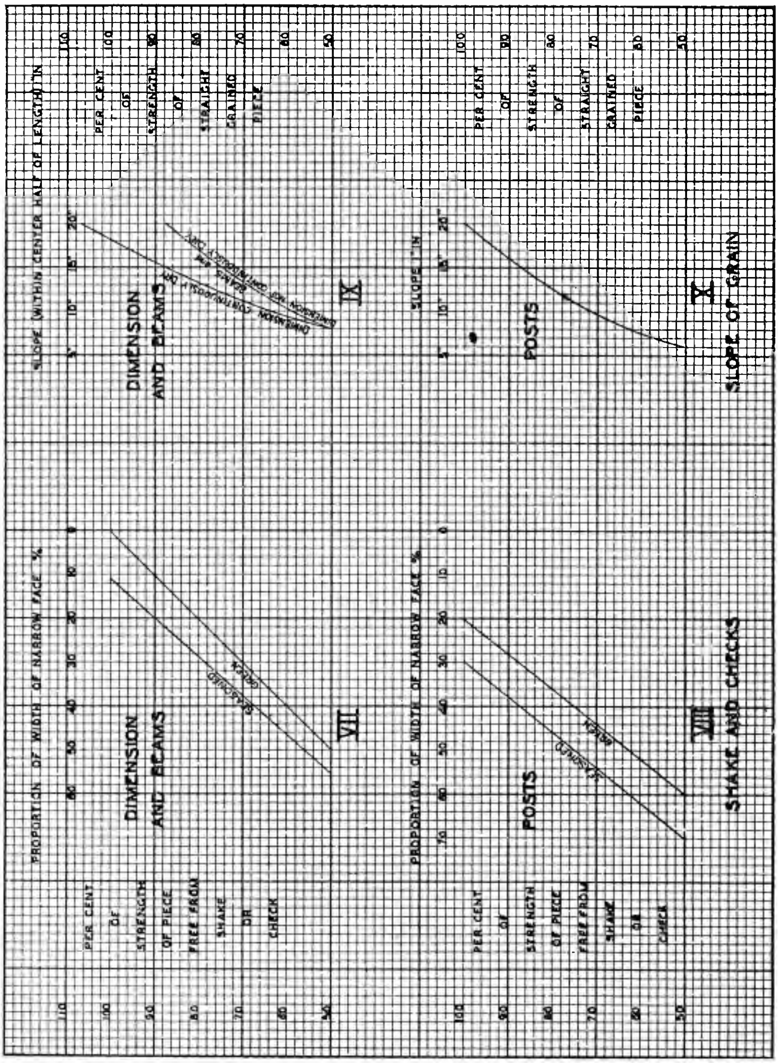
S = strength of piece in relation to strength of green, clear wood.
D = strength of dry dimension in relation to strength of green, clear wood in grades having 50 per cent or more of the strength of clear wood.
k = size of knots in inches.
b = width of narrow or horizontal face in inches.
h = depth of wide or vertical face of dimension or beam in inches, or width of face of post—narrow face if not square.

Development of Formulas

Chart I—1a1, 2a; Chart II—1a2

Knots on narrow faces of dimension or beams reduce strength in direct proportion to their size. (Basis of Development of Structural Grades, paragraphs 9 and 11.) Knot sizes are increased proportionately to widths of faces on widths 6 inches or less. On faces wider than 6 inches, increase is proportional to the square root of the ratio of the wider faces to 6. (Basis of Development of Structural Grades, paragraph 14.)


KNOTS
I
KNOTS ON NARROW FACES
IN CENTER THIRD OF LENGTH
(a) BEAMS
(b) DIMENSION NOT CONTINUOUSLY DRY
II
KNOTS ON NARROW FACES
IN CENTER THIRD OF LENGTH
DIMENSION CONTINUOUSLY DRY
III
KNOTS AT EDGES OF WIDE FACES
IN CENTER THIRD OF LENGTH
DIMENSION NOT CONTINUOUSLY DRY
IV
KNOTS AT EDGES OF WIDE FACES
IN CENTER THIRD OF LENGTH
DIMENSION CONTINUOUSLY DRY
V
1. KNOTS ON CENTER LINES OF WIDE FACES
(a) BEAMS
(b) DIMENSION NOT CONTINUOUSLY DRY
2. KNOTS IN POSTS
ON ALL FACES BUT COVERED BY NARROW FACES NOT SQUARE
VI
KNOTS ON CENTER LINES OF WIDE FACES
DIMENSION CONTINUOUSLY DRY
SIZE OF KNOT IN INCHES
PER CENT OF STRENGTH OF GREEN CLEAR WOOD
WIDTH OF FACE



SLOPE (WITHIN CENTER HALF OF LENGTH) IN
PER CENT OF STRENGTH OF STRAIGHT GRAINED PIECE
DIMENSION AND BEAMS
IX
SLOPE 1 IN
POSTS
X
SLOPE OF GRAIN
PROPORTION OF WIDTH OF NARROW FACE %
PER CENT OF STRENGTH OF PIECE FREE FROM SHAKE OR CHECK
DIMENSION AND BEAMS
SEASONED
GREEN
VII
POSTS
VIII
SHAKE AND CHECKS

1a1

Face 6 inches or less

2a

$$S = 1 - \frac{k}{b}$$

$$\frac{k}{b} = 1 - S \qquad (1)$$

$$k = (1 - S)\, b \qquad (2)$$

Face 6 inches or more

$$k = \sqrt{\frac{b}{6}}\,(1 - S)\, 6$$

$$k = (1 - S)\, \sqrt{6\,b} \qquad (4)$$

$$\frac{k}{\sqrt{6\,b}} = 1 - S$$

$$S = 1 - \frac{k}{\sqrt{6\,b}} \qquad (3)$$

1a2

Face 6 inches or less

$$D = \frac{3}{2} S - .25$$

$$D = \frac{3}{2}\left(1 - \frac{k}{b}\right) - .25$$

$$D = 1.50 - \frac{3\,k}{2\,b} - .25$$

$$D = 1.25 - \frac{3\,k}{2\,b} \qquad (5)$$

$$\frac{3\,k}{2\,b} = 1.25 - D$$

$$k = (1.25 - D)\, \frac{2}{3}\, b \qquad (6)$$

Face 6 inches or more

$$k = \sqrt{\frac{b}{6}}\left(1.25 - D\right)\frac{2}{3} \times 6$$

$$k = (1.25 - D)\,\frac{2}{3}\,\sqrt{6\,b} \qquad (8)$$

$$\frac{k}{\frac{2}{3}\sqrt{6\,b}} = 1.25 - D$$

$$D = 1.25 - \frac{3\,k}{2\,\sqrt{6\,b}} \qquad (7)$$

Chart III—1b1. Chart IV—1b2

In dimension sizes, strength is measured by the square of the effective depth, assuming the knot in its worst position, at the edge of the piece. (Basis of Development of Structural Grades, paragraph 10.) Knot sizes are increased proportionately to widths of faces on width 12 inches or less. On faces wider than 12 inches, increase is proportional to the square root of the ratio of the wider faces to 12. (Basis of Development of Structural Grades, paragraph 14.)

1b1

Face 12 inches or less

$$S = \left(1 - \frac{k}{h}\right)^2 \qquad (9)$$

$$1 - \frac{k}{h} = \sqrt{S}$$

$$\frac{k}{h} = 1 - \sqrt{S}$$

$$k = (1 - \sqrt{S})\,h \qquad (10)$$

Face 12 inches or more

$$k = \sqrt{\frac{h}{12}}\,(1 - \sqrt{S})\,12$$

$$k = (1 - \sqrt{S})\,\sqrt{12\,h} \qquad (12)$$

$$\frac{k}{\sqrt{12h}} = 1 - \sqrt{S}$$

$$\sqrt{S} = 1 - \frac{k}{\sqrt{12h}}$$

$$S = \left(1 - \frac{k}{\sqrt{12h}}\right)^2 \qquad (11)$$

1b2

Face 12 inches or less

$$D = \frac{3}{2} S - .25$$

$$D = \frac{3}{2}\left(1 - \frac{k}{h}\right)^2 - .25 \qquad (13)$$

$$\left(1 - \frac{k}{h}\right)^2 = \frac{2}{3}(D + .25)$$

$$1 - \frac{k}{h} = \sqrt{\frac{2}{3}(D + .25)}$$

$$k = \left(1 - \sqrt{\frac{2}{3}(D + .25)}\right) h \qquad (14)$$

Face 12 inches or more

$$k = \sqrt{\frac{h}{12}}\left(1 - \sqrt{\frac{2}{3}(D + .25)}\right) 12$$

$$k = \left(1 - \sqrt{\frac{2}{3}(D + .25)}\right) \sqrt{12h} \qquad (16)$$

$$\frac{k}{\sqrt{12h}} = 1 - \sqrt{\frac{2}{3}(D + .25)}$$

$$\sqrt{\frac{2}{3}(D + .25)} = 1 - \frac{k}{\sqrt{12h}}$$

$$\frac{2}{3}(D + .25) = \left(1 \frac{k}{\sqrt{12h}}\right)^2$$

$$D = \frac{3}{2}\left(1 - \frac{k}{\sqrt{12h}}\right)^2 - .25 \qquad (15)$$

Chart V—1c1, 2b, 3a. Chart VI—1c2

Knots on center lines of wide faces of dimension, and wide or vertical faces of beams, and on all faces of posts, reduce strength in direct proportion to their size. (Basis of Development of Structural Grades, par. 9 and 11.) Knot sizes are increased proportionately to widths of faces on widths 12 inches or less. On faces wider than 12 inches, increase is proportional to the square root of the ratio of the wider faces to 12. (Basis of Development of Structural Grades, paragraph 14.)

1c1, 2b, 3a

Face 12 inches or less

$$S = 1 - \frac{k}{h} \qquad (17)$$

$$\frac{k}{h} = 1 - S$$

$$k = (1 - S)\, h \qquad (18)$$

Face 12 inches or more

$$k = \sqrt{\frac{h}{12}}\,(1 - S)\, 12$$

$$k = (1 - S)\,\sqrt{12\, h} \qquad (20)$$

$$\frac{k}{\sqrt{12\, h}} = 1 - S$$

$$S = 1 - \frac{k}{\sqrt{12\, h}} \qquad (19)$$

1c2

Face 12 inches or less

$$D = \frac{3}{2} S - .25$$

$$D = \frac{3}{2}\left(1 - \frac{k}{h}\right) - .25$$

$$D = 1.50 - \frac{3\, k}{2\, h} - .25$$

$$D = 1.25 - \frac{3\, k}{2\, h} \qquad (21)$$

$$\frac{3k}{2h} = 1.25 - D$$

$$k = (1.25 - D)\frac{2}{3}h \qquad (22)$$

Face 12 inches or more

$$k = \sqrt{\frac{h}{12}}\left(1.25 - D\right)\frac{2}{3} \times 12$$

$$k = (1.25 - D)\frac{2}{3}\sqrt{12h} \qquad (24)$$

$$\frac{k}{\frac{2}{3}\sqrt{12h}} = 1.25 - D$$

$$D = 1.25 - \frac{3k}{2\sqrt{12h}} \qquad (23)$$

Effect of Shake and Checks

Chart VII

In dimension and beams, shake in green timber is assumed to reduce shearing stress in direct proportion to its extent. A greater amount of shake is permitted in seasoned timber, made up for by the increased resistance of the remaining cross section when seasoned. In green material, shake is permitted in direct proportion of increase from none in a grade of the strength of green, clear wood to ½ the width of the piece in a grade having one-half the strength of green, clear wood. In seasoned material, shake is similarly permitted from 1/9 the width of the piece in a grade of the strength of green, clear wood to 5/9 the width of the piece in a grade having one-half the strength of green, clear wood. (Structural Grades of Lumber and Timber and the Method of Their Derivation, paragraphs 24 and 25.)

Chart VIII

In posts and timbers, shake in green material is permitted in direct proportion of increase from 2/10 the width of the piece in a grade of the strength of green, clear wood to 6/10 the width of the piece in a grade having one-half the strength of green, clear wood. In seasoned material, shake is similarly permitted from 3/10 the width of the piece in a grade having the strength of green, clear wood to 7/10 the width of the piece in a grade having one-half the strength of green, clear wood. (Structural Grades of Lumber and Timber and the Method of Their Derivation, paragraph 27.)

Effect of Slope of Grain

Chart IX

There is not much reduction in strength from cross grain in a piece of dimension or in a beam until a slope of 1 in 40 is reached. From that slope in a beam of a grade having the strength of green, clear wood, slope of grain is limited to 1 in 20 in a grade having seven-eighths this strength, to 1 in 15 in a grade of three-fourths, 1 in 11 in a grade of five-eighths, and 1 in 8 in a grade of one-half the strength of green, clear wood. (Structural Grades of Lumber and Timber and the Method of Their Derivation, paragraph 30.)

Chart X

Slope of grain in a post or column is limited to 1 in 20 in a grade having the strength of green, clear wood, 1 in 15 in a grade of seven-eighths this strength, of 1 in 11 in a grade of three-fourths, 1 in 8 in a grade of five-eighths, and 1 in 6 in a grade having one-half the strength of green, clear wood. (Structural Grades of Lumber and Timber and the Method of Their Derivation, paragraph 31.)

Appendix C

(3) STUDY AND REPORT ADVANTAGE OF ESTABLISHING SUPPLY YARDS FOR STANDARD TRESTLE TIMBERS AT VARIOUS LOCATIONS THROUGHOUT THE COUNTRY

S. F. Grear, Chairman, Sub-Committee; F. E. Bates, E. H. Brown, C. H. Chapin, C. R. Chevalier, F. H. Cramer, R. P. Hart, W. B. Hodge, C. J. Hogue, R. E. Miller, G. W. Rear, J. R. Sexton.

In 1927 a questionnaire was sent to members of the Association and a summary of the replies was submitted to the 1928 Convention, and is printed on page 510 of the 1928 Proceedings. This questionnaire indicated that only a very few of the members of the Association who replied favored the establishing of such yards, and the suggestions for locations were so varied that the establishing of either commercial or joint railroad yards does not seem to be a feasible proposition.

Since the 1928 Convention the Committee has made some investigation of the prices of timbers purchased from commercial yards, as compared with mill prices, and it was found that the increase is about one-third. It is to be expected that the handling of material through a joint railroad yard would increase the cost by approximately this same amount.

The 1921 Proceedings show a statement of the sizes of standard bridge timbers used by fifty-three railroads and shows a diversity of sizes and lengths as follows:

Caps	13 different sizes
Stringers	37 different sizes
Ties	15 different sizes
Guard Rail	9 different sizes

The 1927 questionnaire mentioned above brought out evidence to show there had been very little progress toward decreasing the number of sizes.

The Committee has also found that in general the railroads which have any large amount of timber trestles have store yards of their own with facilities for prompt loading, and the replacements necessarily keep a certain amount of material moving and this is sufficient to take care of emergency needs. In some cases it is found that such material is supplied to other railroads in emergencies.

Conclusion

With the data as given above, the Committee feels that it is not proper for the railroads to attempt to establish joint supply yards, and that with the cost and diversity of sizes it is more satisfactory to purchase material from the mills than from commercial yards, and recommends that this subject be dropped from further consideration by the Association.

Appendix D

(4) STUDY AND REPORT ON OVERHEAD WOODEN BRIDGES

H. Austill, Chairman, Sub-Committee; F. E. Bates, C. H. Chapin, F. H. Cramer, S. F. Grear, A. H. Henckel, J. B. Maddock, R. E. Miller, H. Norris, C. E. Paul, G. W. Rear, G. C. Tuthill, J. L. Vogel, Wm. Walkden.

On July 6th, 1928, the following questionnaire was addressed to representative railways:

"1. Do you at present construct such bridges of timber?
2. Do you consider density of population in the adoption of loads for which you design such bridges?
3. What type of wearing surface have you found most suitable for floors of such bridges?
4. Do you use the A.R.E.A. formula (page 166, Proceedings, 1923) for determining the load carried by one stringer? If not, what formula is used?
5. Please forward a copy of your standard plans and specifications or of a typical plan of such bridges on your railway."

Eighty-five replies have been received, and, of these, thirty-five railways reported that they build such bridges of timber and fifty that they do not. Of the latter, nine have no such bridges on their line. Six state definitely that their reason for not building such bridges of timber is on account of other types of construction being more permanent.

This would indicate that the value of timber for structural purposes may be underestimated. Of the railways that reported having overgrade highway bridges, forty-six per cent use some timber construction.

There are many wooden buildings that have given service for more than a century. A vast amount of timber that has been buried below the ground water line or submerged in streams or lakes is still in perfect preservation after hundreds of years. It is, therefore, evident that the useful life of timber in structures is dependent upon preservation and protection from mechanical wear, or protection from the destructive elements.

Air, moisture and warmth are necessary for decay in timber. Eliminate any one of these and the life of timber will be indefinite. Fungi, bacteria and insects being the cause of decay in timber, if the timber is impregnated with a substance poisonous to these, obviously the life of the timber will be dependent upon its retention of the poisonous substance.

The Committee believes that, with the development of paint spray machines, it will be feasible, practical and economical to spray timber structures with chemicals the same as used in the original treatment, at intervals so as to make the life of the structure entirely suitable to the purpose for which it was originally built.

With this method the chemical can be put in checks, joints and bearings where decay usually starts and timber so treated after it has been in service sufficiently long to have completed the shrinking and checking, common to the material, should require additional spraying only at considerable time intervals.

Attention is invited to an article in *Engineering News-Record* of Septimber 6th, 1928, in which it is stated that after forty-five years the Lake Pontchartrain trestle of the Southern Railway has 97.2 per cent of the creosoted stringers in service.

Also to Vol. 27 A.R.E.A., page 903, from which is quoted:

"Mr. A. F. Robinson, Bridge Engineer of the Santa Fe, in a paper before the Western Society of Engineers and American Wood Preservers' Association in 1922, stated that creosoted ballast deck structures on their line from sixteen to twenty years old seemed to be in perfect condition, and gave promise of being good for fifteen or twenty years of additional service.

"Bridge Engineers on various roads have reported their estimate of life of creosoted trestles anywhere from twenty-five to thirty-five years. The Southern Pacific, with more than 130 miles of creosoted pile trestle and 3000 creosoted timber drain boxes, state from their experience they feel that an average life of thirty years can be expected, and further state that they have hundreds of structures twenty-nine years old that are in good condition and thousands twenty-five years old that give every promise of still being good when they reach the age of thirty years."

Few apply preservatives to structural timber once it is in the structure except for esthetic purposes.

Of course, a timber structure is subject to destruction by fire, but there are wood preservatives that are also fire retarding, and, since the floor of highway bridges can easily be made fairly weatherproof, the tendency for such preservatives to leach out is much less than in more exposed structures.

As to fire hazard of creosoted timber, in the 1925 Proceedings A.R.E.A., Report of Committee on Wood Preservation, the following statement occurs:

"We have a few notable examples to prove that creosoted material when dry is not as susceptible to fire as untreated material, and it is no harder to put out than untreated material. In most cases creosoted timber will stop burning after the excess oil has passed out of the wood, as it only burns as long as the heat converts the oil into gas, and when the excess oil is exhausted the fire goes out."

Due to the ease of framing, in original construction, the facility with which such structures can be reinforced, widened, repaired and trued up, timber is well suited for the construction of overgrade highway bridges.

It is admitted, of course, that, as any material of construction, timber has its limitations, and these apply particularly to beam spans. However, it also is ideally suited to many types of structures, and it is thought that for these it should not be overlooked.

The Committee feels that the timber overgrade highway bridge is not necessarily a temporary structure, and that it has a very definite field of use.

The Committee expects to develop plans of such structures so that they may be used as a guide, and solicits criticism and suggestions from the membership while expressing thanks and appreciation for the information and help already given it.

PROGRESS REPORT OF SPECIAL COMMITTEE ON STRESSES IN RAILROAD TRACK

A. N. Talbot, *Chairman;*
C. B. Bronson,
John Brunner,
W. J. Burton,
Chas. S. Churchill,
W. C. Cushing,
C. W. Gennet, Jr.,
H. E. Hale,
J. B. Jenkins,
George W. Kittredge,
W. M. Dawley, *Vice-Chairman;*
Paul M. LaBach,
C. G. E. Larsson,
G. J. Ray,
Albert Reichmann,
H. R. Safford,
Earl Stimson,
F. E. Turneaure,
J. E. Willoughby,
Committee.

To the American Railway Engineering Association:

The Special Committee on Stresses in Railroad Track, co-operating with a similar committee of the American Society of Civil Engineers, has continued its work, both the experimental investigation and the study of the data of the tests. With the consent of the President and the Secretary of the Association, however, it has been considered best to delay the publication of the Fifth Progress Report of the Committee and to print it in a number of the Bulletin later than the date of the Annual Convention. The postponement of publication was found to give relief to the pressure of publication work in the office of the Secretary, especially as the date at which the report could be presented was necessarily late. Publication prior to the Annual Convention, too, would necessarily have involved the presentation of some of the matter in an incomplete or unfinished form. The material to be presented is of a nature that cannot very well be presented in parts—at least, its presentation at one time will be much more satisfactory. In the time before its printing the Committee will endeavor to add to the interpretation of the results and to make a further expression of the meaning of some of the information and to extend the discussion.

The tests relate to the rail-joint and to the general conditions of track. The report consists of (1) the general structural action of the rail-joint; (2) the mechanics of the rail-joint; (3) the laboratory tests; (4) the field tests, and (5) general discussion of the information obtained and its relation to the rail-joint in track. The subject as a whole is extensive and complicated; no attempt will be made here to summarize the results. It may be noted that the report contains 28 tables, 105 figures, and many pages of text. Published at a time when other new Bulletins are not at hand, it is hoped that its appearance will result in a wider study of the matter than would be otherwise feasible if it were published at the regular time.

Respectfully submitted,

The Special Committee on Stresses Railroad Track,

By A. N. Talbot, *Chairman.*

Bulletin 314, February, 1929.

REPORT OF COMMITTEE XXIV—CO-OPERATIVE RELATIONS WITH UNIVERSITIES

ROBERT H. FORD, *Chairman;*
J. B. AKERS,
FREDERICK BASS,
G. E. BATES,
G. D. BROOKE,
J. L. CAMPBELL,
W. J. CUNNINGHAM,
W. C. CUSHING,
W. M. DANIELS,
L. A. DOWNS,
J. M. R. FAIRBAIRN,
W. D. FAUCETTE,
F. W. GREEN,
H. P. HASS,
E. T. HOWSON,
C. E. JOHNSTON, *Vice-Chairman;*
M. S. KETCHUM,
W. H. KIRKBRIDE,
C. F. LOWETH,
C. H. MITCHELL,
C. A. MORSE,
A. A. POTTER,
G. J. RAY,
HENRY E. RIGGS,
H. R. SAFFORD,
WM. M. SPLAWN,
C. C. WILLIAMS,
W. P. WILTSEE,
JOHN S. WORLEY,
Committee.

To the American Railway Engineering Association:

The work of the Committee during the year has been largely confined to broadening its sphere through contacts with other organizations and agencies who are working among colleges and major industries along lines similar to the purpose for which this Committee was created; also, in preparing in a more satisfactory manner the mediums through which it will be necessary to work in obtaining replies to the questionnaire to be sent to representative railways, as heretofore recommended.

During the year the Committee has been in touch with or represented at conferences of the National Industrial Conference Board, Society for the Promotion of Engineering Education, Engineering Foundation, American Society Mechanical Engineers, Committee on Public Relations of the Eastern Presidents' Conference, and various other organizations and colleges.

The Committee is hopeful that during the coming year they will be able to satisfactorily develop from the executives, principal officers and employees of representative railways, with college or similar training, some of the essential qualifications and preliminary training, education, etc., which the experience of the railways has found to be necessary in recruiting for its service. It is believed that by this means closer co-operation can be obtained between railway managements and the colleges and a greater use made by them of the educational equipment and facilities for research and investigation than at present. Co-operation of this kind offers many attractive possibilities. For example, as an aid in the solution of one of the principal railway problems for meeting the steadily advancing demands of the public for better and cheaper rail transportation, meanwhile yielding a suitable return to the investor in the same manner as for other major industries.

Bulletin 314, February, 1929.

Our questionnaire has already been approved and endorsed by several of the leading organizations who have been engaged in similar studies in other major industries. The Committee is hopeful that when the data obtained can be assimilated and studied in the light of other information bearing on the problem, the results will be of great value alike to the railways and colleges. It should make possible a better perspective for our college authorities of the character and extent of the railway field and of the training best suited for young recruits who have natural qualifications and aptitude for the railway service as a career.

As indicative of the foregoing, information has reached the Committee during the year from the executive officers of certain railways, which shows in a somewhat striking manner the desirable results evidently being obtained in several of the departments through such co-operation, as well as the value of systematic recruiting on a scale suited to the needs of the service through an established system of selection of young men with a background of suitable college training. While these cannot be taken in any sense as conclusive, they are nevertheless indicative of the advantages that are available to the railways through some co-ordinated plan for a better use of our college facilities, and to that end it is proposed the efforts of this Committee will be directed during the coming year.

Action Recommended

No action is recommended, as the above is essentially a progress report.

Recommendations for Future Work

It is recommended that the subjects already assigned be continued for the following year.

Respectfully submitted,

THE COMMITTEE ON CO-OPERATIVE RELATIONS WITH UNIVERSITIES,

ROBERT H. FORD, *Chairman*.

REPORT OF COMMITTEE IV—RAIL

Earl Stimson, *Chairman;*
E. E. Adams,
Lem Adams,
J. E. Armstrong,
W. J. Backes,
J. B. Baker,
F. L. C. Bond,
C. B. Bronson,
E. E. Chapman,
W. C. Cushing,
J. M. R. Fairbairn,
J. M. Farrin,
L. C. Fritch,
E. A. Hadley,
C. R. Harding,
L. J. F. Hughes,
John D. Isaacs,
C. W. Johns,
A. F. Blaess, *Vice-Chairman;*
H. C. Mann,
Hunter McDonald,
R. Montfort,
J. V. Neubert,
A. W. Newton,
R. L. Pearson,
W. H. Penfield,
G. A. Phillips,
G. J. Ray,
R. T. Scholes,
G. E. Tebbetts,
C. P. VanGundy,
F. M. Waring,
J. E. Willoughby,
W. P. Wiltsee,
Louis Yager,
J. B. Young,

Committee.

To the American Railway Engineering Association:

You Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual.

(2) Continue the study of details of mill practice and manufacture as they affect rail quality and rail failures, giving especial attention to transverse fissure failures, collaborating with the Rail Manufacturer's Technical Committee (Appendix A).

(3) Continue the compilation of statistics of all rail failures, making special study of transverse fissure failures (Appendices B and C).

(4) Continue study of the cause and prevention of rail battering, collaborating with Committee V—Track (Appendix D).

(5) Continue the study of the economic value of different sizes of rail (Appendix E).

(6) Continue the study of the reconditioning of battered or worn rail ends by the electric welding process, with special reference to the effect upon rail (Appendix F).

(7) Continue the study of the drilling and spacing of holes in rails of all weights, and sizes of bolts for use with each weight.

(8) Consider the revision or elimination of the specifications for spring washers, collaborating with Committee V—Track.

(9) Compile information of tests of alloy steel rails, addressing the various railroads for records of such tests as they may have made (Appendix G).

Bulletin 315, March, 1929.

A

(1) Revision of Manual

At the request of the American Electric Railway Engineering Association, the Committee recommends for adoption the following revision of paragraph 401 (b-4) of our "Standard Specification for the Manufacture of Open-Hearth Steel Girder Rails, of Plain, Grooved and Guard Types." This revision is intended to harmonize our standard specification with similar specifications of the American Electric Railway Association, Engineering Section, which association represents the largest users of this type of rail.

It is recommended that paragraph 401 (b-4) reading:

> "Any variation which would affect the fit of the splice bars will not be allowed."

Be changed to read:

> "No change will be allowed in dimensions affecting the fit of splice bars, except that the fishing template approved by the purchaser may stand out not to exceed $\frac{3}{32}$ in. laterally."

Other material for Manual revision proposed by the Committee appears hereinafter in connection with subject (4) Rail Batter, and subject (6) Reconditioning of Battered or Worn Rail Ends.

(2) Mill Practice

In collaboration with the Rail Manufacturer's Technical Committee, an investigation into the cause of shattering cracks in rail steel has been undertaken. Special rails have been made which, during their manufacture, were subjected to different cooling conditions, heat treatments, etc., and these rails are now undergoing service tests in track. Sufficient time has not elapsed to enable any but a progress reoport to be made at this time. This work will be continued.

The completion of the Transverse Fissure Detector Car, which was thought to be imminent at the date of the last A.R.E.A. convention, was considerably delayed due to pick-up electrical contact difficulties occasioned by the high resistance skin which was found to exist on the running surface of rail heads. An entirely new method of pick-up has since been devised which has overcome this difficulty.

The completed detector car successfully passed its acceptance tests on September 13th and 14th, 1928, and was subsequently accepted by the Committee.

On October 14th, after testing 166 track miles of rail on the New York Central, between Beacon and Rensselaer, N. Y., the A.R.A. Detector Car started on its tour of the country under leases to various railroads for maximum periods of six working days each, to enable the engineers of as many roads as possible to familiarize themselves with the usefulness of this device.

The Committee believes that the detector car will not only be a practical device enabling the removal of defective rail from track before failure, but will also afford means of investigation which will add greatly to our knowledge of this type of failure. The history of this development has been summarized to date by W. C. Barnes, Engineer of Tests of the Committee, and will be found in Appendix A.

(3) Rail Failures

The Committee presents rail failure statistics for the period ending October 31, 1927, as Appendix B.

TABLE 1—AVERAGE FAILURES PER 100 TRACK MILES

Year Rolled	Years' Service 1	2	3	4	5
1908	...	...	...	...	398.1
1909	...	...	...	224.1	277.8
1910	...	...	124.0	152.7	198.5
1911	...	77.0	104.4	133.3	176.3
1912	28.9	32.1	49.3	78.9	107.1
1913	12.5	25.8	44.8	69.5	91.9
1914	8.2	19.8	32.9	50.9	74.0
1915	8.9	19.0	34.2	53.0	82.4
1916	11.8	29.2	47.7	70.6	105.4
1917	21.6	38.9	66.0	110.5	137.0
1918	8.9	27.6	54.0	92.8	125.4
1919	14.8	39.4	73.7	104.8	115.7
1920	14.2	32.4	63.1	84.5	119.6
1921	10.9	34.9	56.9	70.9	98.9
1922	15.9	34.8	55.2	80.4	110.0
1923	14.3	33.2	57.6	86.0	...
1924	14.0	33.4	58.3	...	...
1925	15.5	36.6	...	...	...
1926	17.1	...	...	...	...

As was forecast in last year's report, the 1922 rollings, whose period of observation is now concluded, show a slightly higher failure rate than the rollings of 1921. Judging from the four-year record of the 1923 rollings, the five-year failure rate of such rollings will exceed that of the 1922 rollings and will approximate that of the 1920 rollings.

The Committee again presents in the rail failure report a chart showing the rating of mills through the use of traffic density factors, as well as the rating by our usual method.

(3) Transverse Fissures

Transverse fissure statistics have been extended to include all failures from such cause reported up to January 31st, 1928, and are presented as Appendix C. The record now comprises a total of 32,088 transverse fissure rail failures, 4742 of which occurred during the fiscal year 1927.

A marked increase in fissure failures recorded during the last few years is noted as occurring in the first year of service as follows:

1925 rollings, all mills, 29 failures in 1925
1926 rollings, all mills, 50 failures in 1926
1927 rollings, all mills, 114 failures in 1927

(4) Cause and Prevention of Rail Batter

The Committee, in collaboration with Committee V—Track, presents a progress report on this subject in Appendix D, which contains an analysis of the results of batter investigations made on the Boston & Maine Railroad, the Delaware, Lackawanna & Western Railroad and the New York Central Railroad. It also brings up to date the record of the rail batter investigations previously reported on the Nashville, Chattanooga & St. Louis Railway, and includes certain portions which are recommended for inclusion in the Manual.

(5) Economic Value of Different Sizes of Rail

The Committee presents as information in Appendix E, a theoretical study which shows the betterment in stiffness of track, stress in rail, and pressure on subgrade that can be accomplished by increasing the weight of rail. It also includes a practical study showing the cost of owning and maintaining 85-lb. and 90-lb. rails for varying traffic densities on one particular stretch of track. This study will be extended to show the same information for all weights of rail under average conditions.

(6) Reconditioning of Battered or Worn Rail Ends

The Committee presents, in Appendix F, final report of its investigation of the effect upon rail steel of reconditioning by acetylene and electric welding processes.

The following conclusion is submitted for inclusion in the Manual:

> "The reconditioning of rail ends by either electric or oxy-acetylene welding has not been found detrimental to the rail. Either method gives an adequate wearing surface to the rail ends when the metal is properly applied. It provides an economical means for restoring battered rail ends to their true surface, and is recommended as good practice."

(7) Drilling and Spacing of Holes in Rails of All Weights

The Committee finds that a proper study of this subject involves consideration of the underlying subject of rail joint design. Investigations in this connection are under way and will be continued next year. The Committee reports progress on this subject.

(8) Revision or Elimination of the Specifications for Spring Washers

The Committee makes no report on this subject this year.

(9) Tests of Alloy Steel Rails

The Committee presents, in Appendix G, as information, a report on intermediate manganese rail, compiled from information furnished by railroads using this class of rail.

The report covers tonnages purchased by various railroads by mills, year, sections and weights per yard, also information as to specifications, inspection tests and results obtained in service.

Action Recommended

1. That paragraph 401 (b-4) of the "Standard Specifications for the Manufacture of Open-Hearth Steel Girder Rails, of Plain, Grooved and Guard Types," reading:

> "Any variation which would affect the fit of the splice bars, will not be allowed."

Be revised to read:

> "No change will be allowed in dimensions affecting the fit of splice bars, except that the fishing template approved by the purchaser may stand out not to exceed $\frac{3}{32}$ inch laterally."

2. That the report in Appendix A be received as information.

3. That the report in Appendix B be received as information.

4. That the report in Appendix C be received as information.

5. That the revision of the definition of "Batter," the rail batter gage and 24-in. straight edge, the forms for recording of track data and the form entitled "Rail Batter Notes," shown in Appendix D, be adopted as standard for inclusion in the Manual and that the remainder of the report in Appendix D be received as information.

6. That the report in Appendix E be received as information.

7. That final report in Appendix F be approved.

8. That the report in Appendix G be received as information.

Recommendation for Future Work

1. Revision of Manual.

2. Continue the study of details of mill practice and manufacture as they affect rail quality and rail failures, giving special attention to transverse fissure failures, collaborating with the Rail Manufacturer's Technical Committee.

3. Continue the compilation of statistics of all rail failures, making special study of transverse fissure failures.

4. Continue the study of the cause and prevention of rail battering, collaborating with Committee V—Track.

5. Continue the study of the economic value of different sizes of rail.

6. Continue the study of the drilling and spacing of holes in rails of all weights, and sizes of bolts for use with each weight.

7. Continue the study of the revision or elimination of the specifications for spring washers, collaborating with Committee V—Track.

8. Continue the compilation of information of tests of alloy steel and heat treated carbon steel rails, addressing the various railroads for records of such tests as they may have made.

9. Study the branding of tee-rails with a view toward standardization, collaborating with Committee V—Track.

Respectfully submitted,

The Committee on Rail,

Earl Stimson, *Chairman.*

Appendix A

(2) DETECTION OF TRANSVERSE FISSURES IN TRACK

By W. C. Barnes, Engineer of Tests, Rail Committee

The Committee is pleased to confirm the announcement which has already appeared in the technical press that "Transverse Fissures Can Now Be Detected in Track."

Two detector cars, one owned and operated by the American Railway Association and one by the Sperry Rail Service Corporation, are now in actual road service, detecting transverse fissures and other defects in rail. At the present writing, a total of 563 track miles of rail has been so tested at an average testing speed of approximately six m.p.h.

The A.R.A. detector car is being routed through the country under lease to various roads for maximum periods of six days each to demonstrate its value and at this time it is operating on the fifth road in its schedule.

The results so far obtained indicate that the prevalence of fissures in rail will vary greatly on different roads. Sufficient mileage has not as yet been tested to enable the drawing of any specific conclusion regarding the number of fissures that may be expected per mile of rail in average track, but the low average of .06%, or one rail in 1,830 rails, found defective in 166 track miles tested on the New York Central Railroad is encouraging in view of the alarming predictions that have emanated from various sources.

On one road 18 rails in which fissures were detected were removed and immediately broken for verification and in each case a fissure was disclosed.

An interesting development is that split heads and webs, crushed heads, horizontal fissures, severe wheel burns and surface cracks are being detected.

It will be remembered that the development of the Sperry electric method of detection was financed by the American Railway Association at the request of the Rail Committee and that the contract entered into provides the terms upon which members of the Association may purchase detector cars.

Its early history is contained in a supplementary report of the Rail Committee dated March 1, 1928, which was distributed at the last Convention, but as this report did not become a matter of record, much of the historical matter contained in it is reproduced herein.

Detection of defects of internal origin in rail heads, particularly of the transverse fissure type, is a problem on which attention and study have been focused for the last fifteen years.

Failures of this type were noted where the development appeared at the surface underneath the rail head and could be traced by the streak of rust at the hairline separation. Mirrors were then constructed on standards or brackets and could be moved along by hand with the reflection from beneath the rail head indicating the location of breaks. The method proved slow, laborious and had the further objection that detection of failures was impossible until the development had reached the contour of the rail section.

The next important development was the experimental work of the Bureau of Standards, commencing in 1915 with a magnetic testing device for this same general purpose. The apparatus was essentially a magnetizing solenoid surrounding the rail, search coils to detect flux leakage at irregularities in the material, and a galvanometer in circuit as the indicator. Subsequently the work initiated at the Bureau was enlarged upon by two railroads and one steel company, but after exhaustive tests over a period of several years the method was discontinued as lacking practical value for application in service. The apparatus, while highly sensitve and accurate, produced results from which it was impossible to differentiate between the effect of slipping of drivers, gagging and cold bending of rails, accidental spike maul blows on the rail, cold rolling effects of wheels, segregation, laminations and head breaks such as transverse fissures.

It was more than three years ago when E. A. Sperry, of the Sperry Development Company, Brooklyn, N. Y., and the inventor of many ingenious devices of great practical value, conceived the idea of utilizing the air-gap resistance effect of dissociated particles or areas in the interior of rail heads to disclose their identity. His method was to force a high current at low voltage through the rail, and by continuously moving a set of conductors along the rail length energize the entire rail. The resistance effect of discontinuities in the head could be detected by a pair of brushes which would pick up the minute potential difference and transmit it to radio amplifying tubes to increase the impulse sufficiently that the needle in a galvanometer would deflect, or else to actuate pens through relays for a permanent paper record.

Mr. Sperry outlined his plans to the Rail Committee, American Railway Engineering Association, three years ago. His proposal and several suggested methods of various types and principles were investigated ("Report on Transverse Fissure Detecting Devices," by W. C. Barnes, Engineer of Tests, A.R.E.A. Proceedings, Volume 28, page 966), and after due consideration the recommendation was made to the Board of Direction for an initial appropriation of $2,000 for a co-operative experimental study in the laboratory of the Sperry Development Company, which was granted.

Laboratory equipment was designed and assembled early in 1927, and failed rails of various weights, sections, rollings and manufacture were furnished by several railroads. The apparatus proved successful from the start, and internal breaks which were only two per cent of the head area were discovered, while the early expectations were that fifteen per cent would likely be the minimum transverse separation within the head that could be detected.

Furthermore, it was demonstrated that unless discontinuities existed in the rail head there was not the slightest deviation of the needle of the galvanometer or movement of the recording pens, indicating that the rails were structurally sound and normal. To check this broad assertion several rail heads were fractured in short lengths under the steam hammer and were entirely free from any indications of internal breaks or separations, and therefore checked the records from the experiments with the testing apparatus.

The operator became so proficient that the size and location in the cross-section of the rail head of each internal transverse fracture could be foretold very accurately. Holes were drilled vertically into the top of the rail head and were so accurately centered that the point of the drill would meet the opposing faces of the fissure within the head. Figure 1 shows the results of an experiment of this kind.

In the course of this experimental work, light of more than usual interest was thrown on the reason why the magnetic method failed to differentiate between the various physical characteristics of the material itself just described and transverse fissures themselves. This was because the transverse fissures could only operate the galvanometer through their functioning as air gaps, which were supposed to interrupt the flow of magnetic lines. Magnetic air gaps form the basis of all industrial uses of magnetism. Especially is this true in all rotating electric generators and motors.

The laws and mathematics governing the magnetic flux in air gaps have become perfectly understood and the reason why the air gap presented by a true transverse fissure gave no useful effect as an air gap, is the fact that the element of length is practically completely wanting and non-existing. This has been proved through the experiment referred to above.

It may be interesting to state that the reason for drilling was to introduce a fluid of the halogen group, which is possessed of extremely small molecules, expecting this fluid to freely penetrate and discolor the two entire opposing faces of the fissure. The interesting fact was developed that after repeated applications of this fluid even under some pressure head the rail was broken at this point and not the slightest penetration could be observed, proving that the actual gap between the surfaces is sub-molecular in dimension and therefore sub-microscopic, because the little spheres representing the smaller molecules of even a halogen not only could not force their way into the crevice, but could not enter it to the slightest extent, leaving the surface bright as shown in the figure.

This is the first scientific proof that we have ever had of the extreme minuteness of the length of the gap longitudinally in the rail and the utter impossibility, therefore, of obtaining any interpretable disturbance in the magnetic flux passing through the rail due to the fissure.

The thorough tests on over fifty rails demonstrated fully that the laboratory equipment had proven the soundness of the basic principles involved, and indicated its promising possibilities.

An agreement was subsequently reached between the Sperry Development Company and the American Railway Association in August, 1927, for the construction of a Track Car to be used under service conditions for the detection and marking of internal failures in rail heads. Pioneering work was required for a new device of this character and although the details and the assembly were pushed as speedily as possible, it was not until the latter part of December, 1927, that the car was ready for tests other than those in the laboratory.

Final acceptance of the Detector Car was made contingent upon a successful and satisfactory road service test under the supervision of the Rail Committee. A test track was selected on the New York Central Railroad in the yard at Beacon, N. Y.—58 miles north of New York City—and was set aside entirely for this purpose. The 650 feet of track was laid with portions of failed rails removed from service, from 8 to 22 feet long, and of various rollings from 1913 to 1925 of the 6-inch 105-lb. Dudley section. Each rail length had developed a transverse fissure in service.

The rails were all first carefully tested by hand, using a portable coil and galvanometer. Subsequently the Detector Car was towed over this track for preliminary trials of the functioning of the apparatus. It was found necessary to make several minor changes for more satisfactory operation.

The Detector Car was then tried out on the main line high speed track to develop the serviceability of the device and determine the most satisfactory operating conditions.

At this time the mechanism for picking up the difference in potential at the internal break in the rail head caused by the resistance effect of the infinitesimal air gap between opposing faces of the fissure, consisted of two small potential brushes which made contact with the head of the rail.

At that time, early in 1928, the successful completion of the Detector Car was thought to be imminent, but extensive service tests demonstrated that the indications obtained of defects in the rail were not entirely reliable because of electrical contact difficulties which were found to be due to a very high resistance skin which exists on the running surface of rails which have been in service. Many attempts were made, with but partial success, to clean this skin from the surface of the rail by means of brushes, grinders, chemicals, etc. A deadlock had been reached which was finally overcome through the development by the Sperry organization of an entirely new method of detection, which, however, required no change in the original Detector Car equipment other than the substitution of a special apparatus for the test contacts previously used.

The new method is based on the fact that any discontinuity of the metal in the rail whether it be a transverse fissure or other fissure or crack lying in a plane at any angle with the longitudinal axis of the rail, or any change in the cross-section of the rail such as results from wheel burns or crushed heads, will abruptly change the direction of the flow of the current forced through the rail at the locations of such obstructions.

The new pick up equipment detects such changes in direction of current flow and acts without contact with the rail surface and hence has completely overcome the former contact resistance difficulties.

Then followed further successful experiments to reduce sparking which occasionally occurs at the main current brushes due to dirty rail. This occasional sparking caused the recording of false indications which, however, could be easily identified as being caused by sparks by examination of the rail, as sparking leaves a very distinctive mark readily discernible on the running surface.

The Detector Car was then submitted for acceptance tests which were made on the New York Central main line tracks in the vicinity of Beacon, New York, on September 13 and 14, 1928, and was accepted by the Committee on October 2, 1928, as being a "practical device for the detection of transverse fissures in track."

The general appearance of the A.R.A. Detector Car is shown in Fig. 2 and consists of a standard track maintenance trailer car upon which is built an enclosure containing the power plant, radio apparatus and recording mechanism. A motor car is required for towing purposes as the Detector Car is not equipped for self-propulsion. The best operating speed is approximately 6 miles per hour.

Fig. 3 shows the power plant placed on the forward end of the platform, and includes a 25 H.P. gas engine, with necessary starter and auxiliaries, directly connected to a 4000 ampere, 2 volt generator operating at 900 r.p.m.

Fig. 4 illustrates the contact brushes on the top surface of the rail. and between which flows the energizing current. Each contact assembly consists of eight individual copper brushes pressed against the rail head by springs. These brushes are mounted in a rigid frame which is raised and lowered by a lever in the car. There are two sets of eight brushes in contact with each line of rails.

The pick-up or detecting device is shown mounted between the main current brushes in close proximity to the running surface of the rail. The minute current impulse originating in the detecting device when it passes over the internal break in the rail head, is carried to a set of radio tubes which amplify it some twenty-five thousand times.

Near the center of Fig. 4, the paint spraying device can be seen. A relay controls the release of a spray of paint against the side of the rail whenever a defect is found at any point in the length of the rail.

Fig. 5 shows the table containing the necessary batteries for the tubes. Above the table is shown the cases containing the amplifiers. Above the amplifiers are the relays, ten being required for various purposes.

Fig. 6 shows the recording table on top of which travels a friction driven moving strip of paper. Directly in contact with the paper are seven pens which are actuated by the relays in circuit with the tubes.

Fissures located in one line of rails are indicated on the paper by three pens, and a similar set of pens for the opposite line of rails. The center pen records location of joints. The relays are so adjusted that a short transverse line is drawn by one pen if the internal break is of small area; two pens operate if the break is of intermediate size and all three pens if of large area.

The three lines to the left record defects in the left hand rail; the middle lines locate the joints; the three right hand lines indicate defects in the right hand line of rails. The short transverse lines thus permanently record the location of internal breaks and their size or area. The paint spray notifies the trackmen of the existence and location of defective rails.

Rotary scratch brushes, shown in Fig. 7, are set ahead of the front contact brushes and remove rust or foreign material from the running surface of the rail to insure good contact for the brushes.

The writer wishes to express his appreciation to the Railway Age which furnished several of the cuts used herein.

Fig. 1. Showing Drilled Fissure

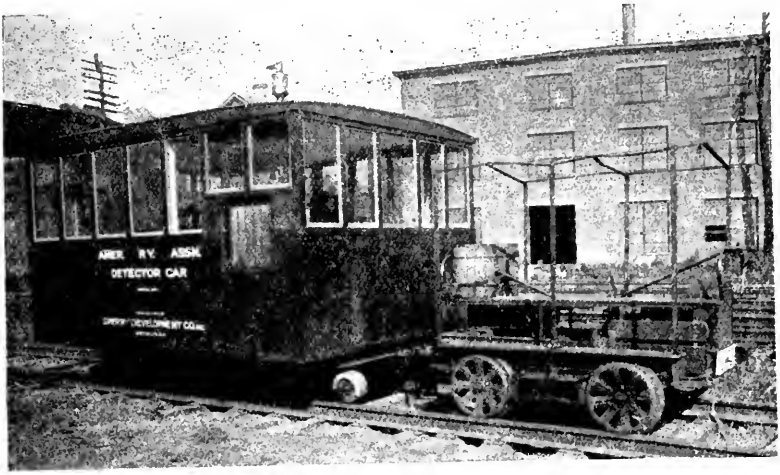


Fig. 2. Side View of A.R.A. Detector Car

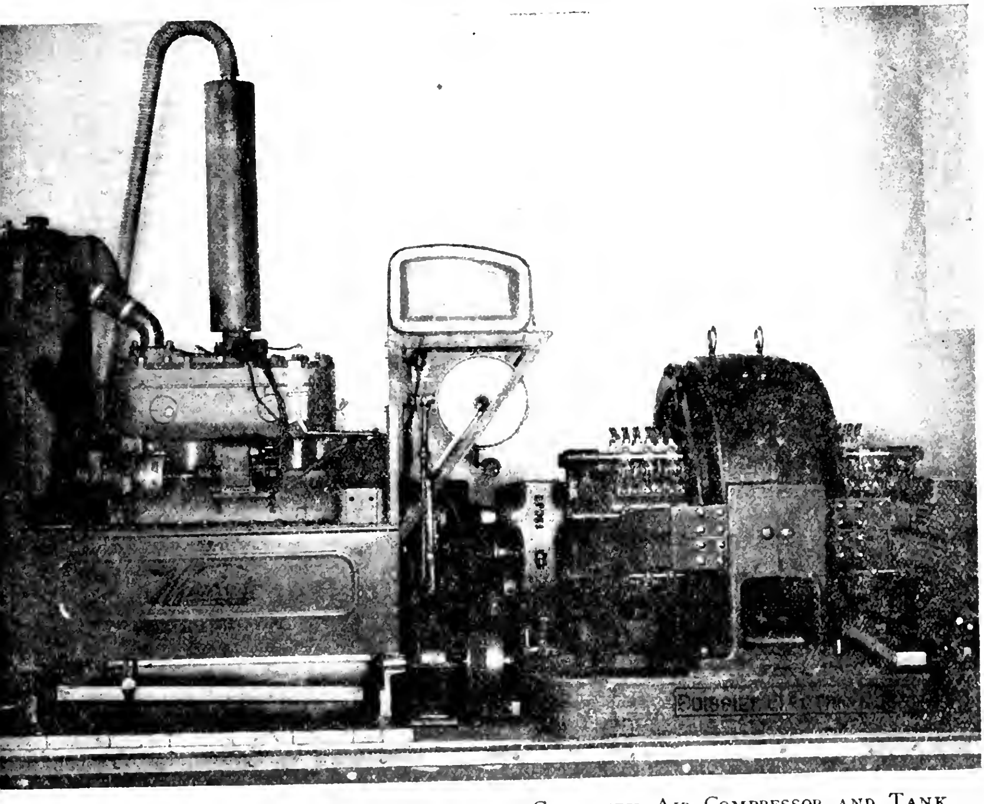


Fig. 3. Gasoline Generating Set Assembled on Car, with Air Compressor and Tank

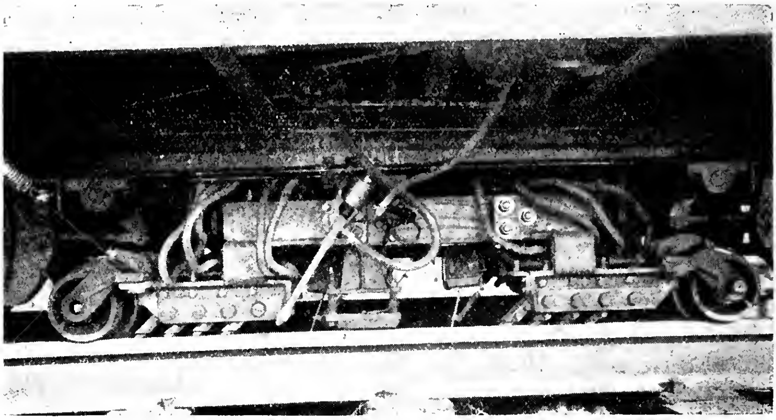


Fig. 4. View Showing Detail of Two Main Current Brushes in Contact with Rail and the Pick-Up Unit Located Between Them. Also Shows Nozzle of Paint Gun for Automatic Marking of the Fissures.

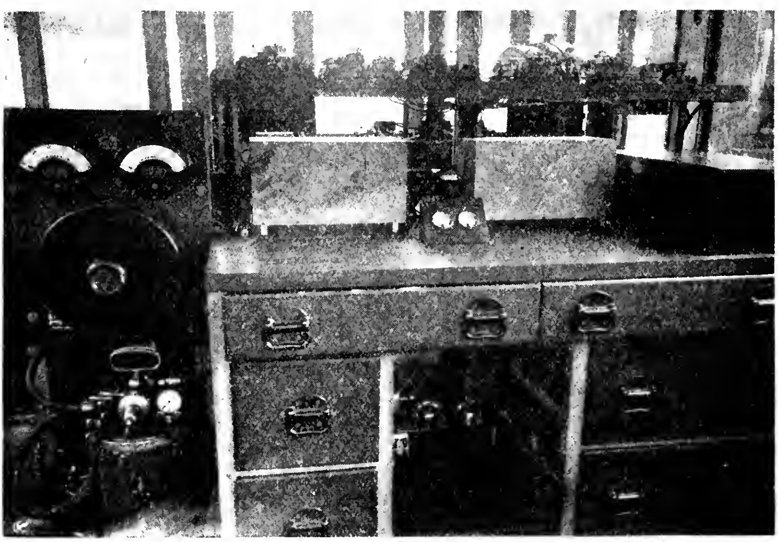


Fig. 5. Amplifier Table Showing Shielded Amplifiers and Relays.

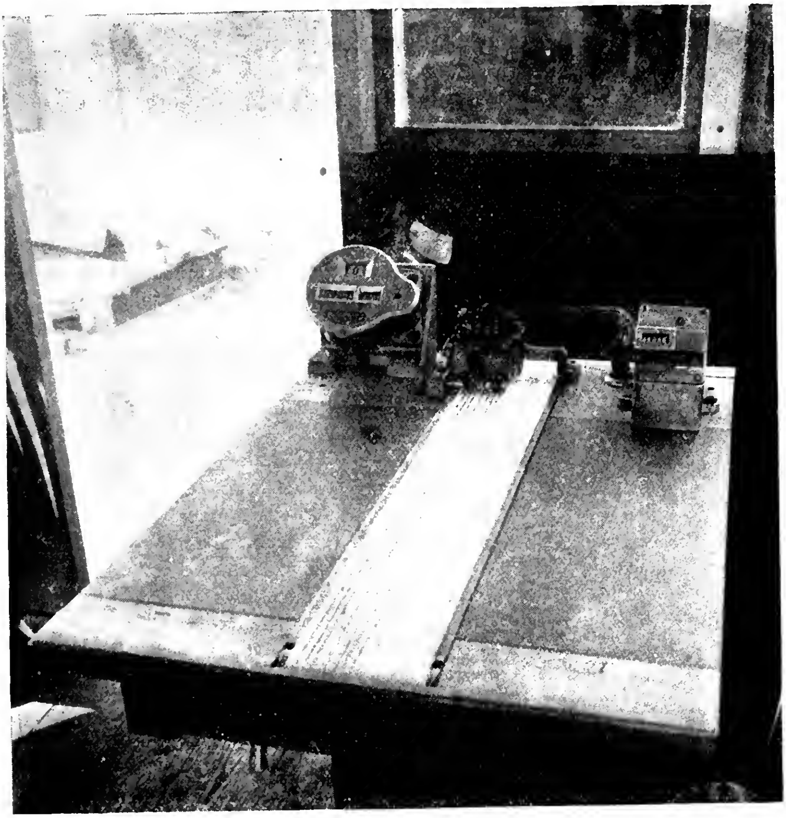


FIG. 6. RECORDER TABLE SHOWING TYPICAL RECORD OF RAIL JOINTS AND VARIOUS SIZE FISSURES

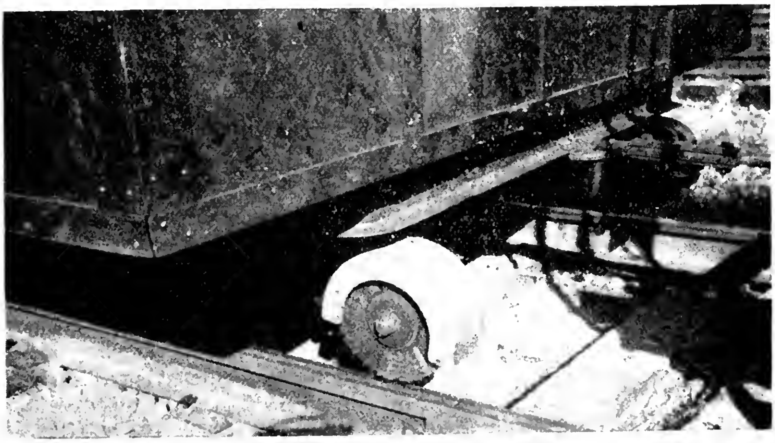


FIG. 7. VIEW SHOWING ROTARY SCRATCH BRUSHES FOR CLEANING RUNNING SURFACE OF RAIL

Appendix B

(3) RAIL FAILURE STATISTICS FOR 1927

By W. C. Barnes, Engineer of Tests, Rail Committee

The rail failure statistics for the year ending October 31, 1927, appearing in this report, have been compiled in accordance with the standard method of basing the failure rate on mile years of service in track.

The rollings for 1922 and succeeding years are embodied in these statistics, the tonnages and track miles reported being as follows:

Year Rolled	*Tons*	*Track Miles*
1922	1,103,583	6,997
1923	1,520,046	9,657
1924	1,434,165	9,036
1925	1,673,656	10,345
1926	1,720,748	10,380
Totals	7,452,198	46,415

Table 1 shows the average failures per 100 track miles which occurred in one to five years' service of all of the rail reported on, from all mills together with the results taken from previous reports, including both Bessemer and Open-Hearth rails. The 1922 rollings, whose period of observation is now concluded, show a slightly higher failure rate than the rollings of 1921, as was forecast in last year's report. The four-year record of the 1923 rollings indicates that no improvement in their failure rate can be expected in next year's report.

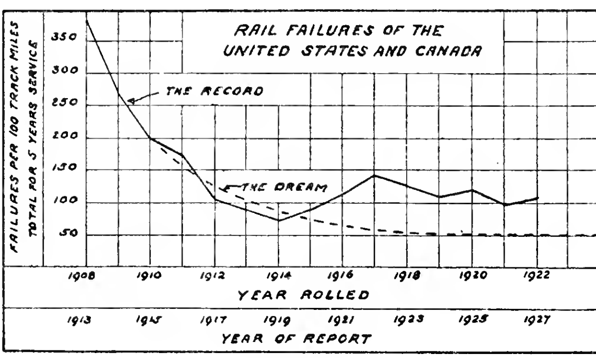


Fig. 1.

Fig. 1 shows diagrammatically the five year averages from Table 1.

Table 2 presents a summary from 15 years' reports showing track miles of rail originally laid and total failures in addition to the failures per average 100 track miles in service, for periods of one to five years, from Table 1. The average results of the rails from each of the mills for rollings since 1908 are given in Table 3 and these results are shown diagrammatically in Fig. 2.

Table 4 and Fig. 5 present the performances of rails rolled at each of the mills shown, during the five year period covered. In Table 4 the failures per 100 track miles per year of service are shown and the weighted average is given for the rollings from 1922 to 1926, inclusive, for each mill. These averages, which take into account the mileages

TABLE 1—AVERAGE FAILURES PER 100 TRACK MILES.

Year Rolled	YEARS SERVICE 1	2	3	4	5
1908	-	-	-	-	398.1
1909	-	-	-	224.1	277.8
1910	-	-	124.0	152.7	198.5
1911	-	77.0	104.4	133.3	176.3
1912	28.9	32.1	49.3	78.9	107.1
1913	12.5	25.8	44.8	69.5	91.9
1914	8.2	19.8	32.9	50.9	74.0
1915	8.9	19.0	34.2	53.0	82.4
1916	11.8	29.2	47.7	70.6	105.4
1917	21.6	38.9	66.0	110.5	137.0
1918	8.9	27.6	54.0	92.8	125.4
1919	14.8	39.4	73.7	104.8	115.7
1920	14.2	32.4	63.1	84.5	119.6
1921	10.9	34.9	56.9	70.9	98.9
1922	15.9	34.8	55.2	80.4	110.0
1923	14.3	33.2	57.6	86.0	
1924	14.0	33.4	58.3		
1925	15.5	36.6			
1926	17.1				

represented in each of the five years' rollings, are presented diagrammatically in Fig. 3, in which the mills are listed from top down in descending order of merit. Inland, which is now on a par with other mills for comparative purposes, shows the lowest rate of failure, 8.0 failures per 100 track miles per year, closely followed by Illinois with 8.3. Colorado has moved up to third place with 11.2, with Bethlehem, Carnegie and Pennsylvania following with 16.0, 16.0 and 16.2, respectively. The high rate of failure of Tennessee rail continues with an average for the rollings included this year of 45.4. Due to absence of reports on Cambria

TABLE 2—SUMMARY FROM FOURTEEN YEARS' REPORTS SHOWING TRACK MILES ORIGINALLY LAID. TOTAL FAILURES AND FAILURES PER 100 AVERAGE TRACK MILES IN SERVICE.

Service	Five Years			Four Years			Three Years			Two Years			One Year		
	Trk Mls Of Rail Laid	Failures		Trk Mls of Rail Laid	Failures		Trk Mls of Rail Laid	Failures		Trk Mls of Rail Laid	Failures		Trk Mls of Rail Laid	Failures	
		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls		Total	Per 100 Trk Mls
From 1913 Report															
Year Rolled Totals	3201.35	1908 12746	398.1	6340.54	1909 14208	224.1	9860.18	1910 12227	124.0	6536.05	1911 5030	77.0	7105.74	1912 2050	28.9
From 1914 Report															
Year Rolled Totals	6697.39	1909 18605	277.8	10024.85	1910 15309	152.7	6096.48	1911 6354	104.4	7610.60	1912 2431	32.1	8775.44	1913 1095	12.5
From 1915 Report															
Year Rolled Totals	11587.43	1910 22981	198.5	7980.75	1911 10635	133.3	10374.18	1912 5119	49.3	10668.59	1913 2756	25.8	7061.24	1914 584	8.2
From 1916 Report															
Year Rolled Totals	7969.41	1911 14052	176.3	10260.93	1912 8100	78.9	11335.41	1913 5076	44.8	7505.24	1914 1483	19.8	7381.29	1915 656	8.9
From 1917 Report															
Year Rolled Totals	10778.68	1912 11546	107.1	12526.60	1913 8706	69.5	7819.79	1914 2576	32.9	7344.65	1915 1395	19.0	8532.53	1916 1004	11.8
From 1918 Report															
Year Rolled Totals	11883.57	1913 10924	91.9	7752.27	1914 3948	50.9	7072.23	1915 2414	34.2	8347.44	1916 2439	29.2	7384.26	1917 1596	21.6

From 1919 Report															
Year Rolled Totals	7917.26	1914 5855	74.0	7280.51	1915 3862	53.0	8407.55	1916 4013	47.7	7615.46	1917 2962	38.9	6354.44	1918 568	8.9
From 1920 Report															
Year Rolled Totals	7346.50	1915 6057	82.4	8062.10	1916 5691	70.6	7334.40	1917 4844	66.0	6658.80	1918 1837	27.6	6676.60	1919 986	14.8
From 1921 Report															
Year Rolled Totals	7820.14	1916 8248	105.4	7025.25	1917 7765	110.5	6313.98	1918 3414	54.0	6271.82	1919 2477	39.4	7341.71	1920 1044	14.2
From 1922 Report															
Year Rolled Totals	6945.43	1917 9533	137.0	6117.93	1918 5681	92.8	6402.43	1919 4719	73.7	7550.63	1920 2448	32.4	7421.29	1921 806	10.9
From 1923 Report															
Year Rolled Totals	5756.11	1918 7221	125.4	6388.57	1919 6697	104.8	7200.83	1920 4545	63.1	7338.52	1921 2568	34.9	7116.16	1922 1135	15.9
From 1924 Report															
Year Rolled Totals	5913.86	1919 6845	115.7	7271.00	1920 6146	84.5	6857.55	1921 3905	56.9	6974.38	1922 2429	34.8	9501.95	1923 1363	14.3
From 1925 Report															
Year Rolled Totals	6576.48	1920 7759	119.6	6640.46	1921 4950	70.9	6765.99	1922 3514	55.2	8692.16	1923 2791	33.2	7804.78	1924 1098	14.0
From 1926 Report															
Year Rolled Totals	7686.27	1921 7376	98.9	7116.14	1922 5594	80.4	9737.02	1923 5454	57.6	9371.49	1924 3130	33.4	10838.62	1925 1701	15.5
From 1927 Report															
Year Rolled Totals	6997.42	1922 7341	110.0	9657.09	1923 7809	86.0	9036.17	1924 5014	58.3	10344.83	1925 3620	36.6	10380.45	1926 1742	17.1

rollings from 1924 to 1926, inclusive, from Dominion from 1922 to 1924, inclusive, and on Maryland rollings from 1922 to 1923, inclusive, these three mils do not appear in Table 4 nor in Fig. 3, 4, and 5.

Fig. 4 which rates the relative performance of the mills from the same data that is used for Fig. 3, except that a traffic density factor has been introduced into the final computations is presented as information. A factor for each reporting road, based on its gross freight ton miles per mile of main track, was applied to the rail tonnages on that road from any given mill and the resulting weighted average traffic density factor, for all rail on all roads from that mill, was applied to the failure rate of that mill's output as given in Fig. 3. In like manner, weighted traffic density factors were obtained and applied for rail from each mill. No claim is made for the entire accuracy for this system of rating, but it does give more consideration to the work which the failed rails from the respective mills are called upon to perform, than does the system of rating on which Fig. 3 is based. Fig. 4 is similar to Fig. 4 of last year's report with the exception that the mills are listed from top down in descending order of merit. The effect of the introduction of the traffic density factors has been to advance Carnegie and Pennsylvania to third and fourth place and to demote Colorado to a position following Bethlehem. In comparing Figs. 3 and 4 with like figures in former reports, it appears that Inland and Illinois have replaced Carnegie at the top of the list.

Table 5 shows the average weight of rails, from various mills and from all mills. The average reported for the year 1926 stands at 105.4 lb. per yard.

TABLE 3—FAILURES FOR VARIOUS AGES OF RAIL PER 100 TRACK MILES.

Year Rld	Years Service 1	2	3	4	5	Years Service 1	2	3	4	5
	Algoma					Bethlehem				
1906					482.9					503.7
1909				203.7					466.1	
1910			431.0		13.8			174.0	245.0	330.9
1911		219.7					113.3	195.3	251.7	329.8
1912	124.0					11.9	32.0	52.1	83.2	106.8
1913						13.4	26.9	52.6	77.3	99.5
1914	19.0	43.2	67.1	67.9	321.4	3.8	6.9	16.0	21.6	33.0
1915	7.1	11.8	22.9	39.1	84.0	17.1	24.5	41.0	65.0	92.4
1916	22.7	42.1	63.4	96.8	139.9	17.7	42.4	75.2	110.9	152.0
1917	2.0	2.0	9.1	29.7	62.9	39.0	59.2	94.8	127.7	157.5
1918						19.6	57.7	78.4	91.5	133.7
1919	7.3	26.6	55.8	82.9	36.7	31.2	72.3	105.0	160.7	213.9
1920	2.6	16.5	41.0	278.5	472.0	10.5	57.5	56.5	84.5	95.5
1921	4.6	13.4	27.0	42.4	65.2	12.9	63.4	88.4	114.3	143.5
1922	17.4	51.7	83.0	125.5	184.4	55.6	77.3	130.6	177.4	223.4
1923	30.3	74.5	115.8	161.8		7.4	18.8	47.0	72.0	
1924	18.5	48.9	85.7			23.2	40.3	52.0		
1925	2.3	7.9				22.9	28.2			
1926	1.2					9.0				
	Cambria					Carnegie				
1908										
1909				244.8	326.6				104.1	137.1
1910			98.5	136.4	201.0			98.9	112.9	101.1
1911		73.7	126.1	227.7	257.2		71.5	108.9	123.1	165.6
1912	17.1	41.8	74.3	108.9	140.9	12.3	30.9	55.3	78.4	98.8
1913	26.7	49.5	78.3	106.2	120.1	8.9	19.4	33.8	62.9	80.0
1914	15.8	37.7	61.9	64.3	137.7	5.5	11.9	16.6	25.4	48.8
1915	6.3	19.5	34.1	58.7	111.5	1.8	8.6	16.9	29.2	43.7
1916	7.3	25.9	33.7	73.7	157.6	4.9	13.2	26.8	45.6	69.7
1917	23.9	38.9	112.9	311.6	394.2	6.1	19.5	39.3	73.3	92.2
1918	32.9	95.5	248.0	369.7	507.4	6.2	41.6	50.2	73.7	125.5
1919	33.3	75.2	82.6	103.2	152.7	8.5	35.9	36.5	46.5	60.8
1920	37.6	44.2	96.8	158.5	223.1	7.0	15.1	34.4	59.4	87.8
1921	13.8	43.2	101.2	158.8	237.4	3.3	8.6	23.6	37.5	52.8
1922	16.1	43.9	62.0	72.0	126.0	8.4	20.4	38.0	48.7	65.5
1923	12.6	36.9	63.3	97.3		4.1	13.9	26.0	45.9	
1924	47.5					10.6	33.8	48.4		
1925						17.1	41.9			
1926						17.2				
	Colorado					Dominion				
1908					45.5					
1909				22.4	34.2					
1910			19.6	23.4	60.9					
1911		15.8	31.0	52.6	84.3					
1912	18.3	40.9	55.6	91.3	117.6					
1913	3.9	11.0	26.0	46.6	82.1					
1914	3.7	7.6	14.1	27.3	42.0					
1915	4.6	7.7	15.1	34.4	80.3					
1916	5.8	15.7	34.5	53.6	78.1					
1917	5.4	12.5	38.7	51.5	42.6					
1918	6.5	13.1	39.7	109.0	184.8		60.0	149.0	420.9	482.7
1919	5.0	18.5	32.9	65.2	90.2	8.7	102.3	185.9	298.3	396.0
1920	9.3	27.6	75.0	96.5	133.3					
1921	9.2	31.7	50.6	72.7	97.8	60.9				
1922	12.0	27.1	58.9	111.6	136.6					
1923	7.0	29.3	54.3	91.5						
1924	4.3	9.6	28.7							
1925	3.8	7.2				2.6	2.6			
1926	2.6					1.3				
	Illinois					Inland				
1908										
1909				151.9	219.7					
1910			88.4	136.8	206.2					
1911		67.5	94.0	107.7	178.6					
1912	7.4	23.2	39.2	64.6	100.0					
1913	10.0	21.9	44.0	62.1	91.5					
1914	11.6	30.0	47.3	83.6	98.3					
1915	10.7	21.9	40.9	56.1	78.8					
1916	11.1	26.0	43.9	70.7	97.3					
1917	9.1	19.9	46.3	75.5	107.7					
1918	2.5	10.8	18.5	45.4	50.3					
1919	11.5	26.8	43.7	77.1	107.1					
1920	5.4	13.3	36.9	55.6	84.2					
1921	4.2	16.2	27.0	41.7	58.9					
1922	5.0	11.2	20.6	29.4	42.6		19.0	35.7	53.1	76.7
1923	6.6	17.2	32.5	51.1		7.6	12.8	20.4	29.5	
1924	5.4	10.9	18.8			2.6	6.7	16.7		
1925	5.6	10.9				5.6	10.4			
1926	8.2					10.7				

Table 3—(Concluded)—Failures for Various Ages of Rail per 100 Track Miles

Year Rld	Years Service					Years Service				
	1	2	3	4	5	1	2	3	4	5
	Lackawanna					Maryland				
1908					143.5					
1909				100.1	117.8					
1910			42.7	90.3	148.9			69.6	104.8	163.7
1911		29.5	57.1	108.6	162.5		32.9	49.5	58.5	67.4
1912	4.8	20.1	39.6	67.1	88.6	11.3	5.8	16.1	8.6	110.8
1913	17.2	31.4	51.9	74.0	115.3	28.6	74.1	88.4	117.0	159.7
1914	1.8	10.0	24.5	49.3	78.7	13.3	25.2	31.4	36.2	62.9
1915	10.5	23.8	38.1	57.3	73.1	24.5	60.2	99.6	138.1	231.4
1916	8.9	25.5	40.1	58.0	76.9	30.7	61.8	92.6	96.6	180.3
1917	16.8	31.6	46.6	78.3	104.5	160.5	214.2	360.5	425.5	445.5
1918	7.4	23.7	43.8	65.5	93.2	23.7	59.2	113.6	139.1	210.2
1919	22.8	51.9	77.4	86.7	153.0	34.2	52.8	60.8	90.8	106.9
1920	14.5	27.1	50.6	74.1	99.0	0.0	2.3	11.9	11.9	
1921	3.8	19.0	41.3	62.4	83.2	0.0	7.2	25.3		
1922	4.0	13.6	22.6	35.6	49.9					
1923	18.6	35.9	57.6	90.8						
1924	18.5	29.3	50.8				1.5	6.0		
1925	16.7	36.0				11.2	62.6			
1926	24.6					31.0				

Year Rld	1	2	3	4	5	1	2	3	4	5
	Pennsylvania					Tennessee				
1908					72.9					86.5
1909				86.3	101.4				11.1	83.7
1910			81.4	110.9	123.8			32.4	47.8	55.2
1911		34.6	79.6	119.0	145.2		14.9	25.1	40.8	61.7
1912	5.3	15.6	27.5	46.8	60.4	7.3	32.9	43.9	64.5	83.2
1913	9.6	21.0	34.7	47.2	71.2	5.7	16.5	24.5	41.6	57.3
1914	8.2	21.1	29.4	38.0	49.7	7.5	16.6	29.0	44.2	60.8
1915	6.3	18.1	27.9	48.4	59.6	6.0	16.0	30.5	48.0	70.9
1916	35.6	46.1	94.2	136.1	171.7	15.6	37.1	61.1	82.2	123.4
1917						17.3	35.7	58.2	102.5	109.5
1918	2.4	9.2	20.7	50.6	76.0	16.4	34.6	79.9	143.1	145.3
1919	46.9	79.6	139.8	175.1	233.8	14.1	34.2	100.7	132.3	79.7
1920	56.3	38.5	73.2	96.7	139.5	39.9	83.1	149.3	189.8	232.4
1921	4.9	12.2	25.9	41.6	66.1	37.5	84.9	149.7	184.7	231.6
1922	10.3	18.7	20.1	29.7	43.9	42.7	106.7	172.0	204.7	264.9
1923	10.0	16.7	31.2	41.1		42.4	100.4	136.2	194.5	
1924	16.6	38.9	65.3			32.6	82.4	136.4		
1925	7.8	34.3				35.5	96.1			
1926	20.2					34.6				

All Mills

Year Rld	Years Service				
	1	2	3	4	5
1908					370.5
1909				163.6	198.5
1910			81.3	107.1	154.0
1911		53.0	83.5	111.2	161.9
1912	26.3	28.9	46.0	74.2	102.7
1913	11.5	24.8	43.3	68.5	90.3
1914	8.0	18.9	30.8	47.4	74.0
1915	8.8	19.0	33.8	53.0	82.4
1916	11.7	27.9	47.7	70.6	105.4
1917	21.8	38.9	66.0	110.5	137.0
1918	8.9	27.6	54.0	92.8	125.4
1919	14.8	39.4	73.7	104.8	115.7
1920	14.2	32.4	63.1	84.5	119.6
1921	10.8	34.9	56.9	70.9	98.9
1922	15.9	34.8	55.2	80.4	110.0
1923	14.3	33.2	57.6	86.0	
1924	14.0	33.4	58.3		
1925	15.5	36.6			
1926	17.2				

TABLE 4—RECAPITULATION—TOTALS AND AVERAGES GROUPED BY MILLS. TRACK MILES—REPRESENTS QUANTITY ORIGINALLY LAID. FAILURES TO DATE—COMPUTED BY MILE YEARS OF RAIL IN SERVICE.

Year	Track Miles	Total Failures	Failures to Date Per 100 Track Miles		Track Miles	Total Failures	Failures Per 100 Track Miles	
			To Date	Per Year			To Date	Per Year
	Algoma				Bethlehem			
1922	365.12	672	184.4	36.9	178.66	389	223.4	44.7
1923	430.39	693	161.8	40.4	948.86	662	72.0	18.0
1924	500.84	429	85.7	28.5	558.64	277	52.0	17.3
1925	479.15	38	7.9	4.0	706.32	194	28.2	14.1
1926	319.36	4	1.2	1.2	924.69	82	9.0	9.0
Totals	2094.86	1836		22.6	3317.17	1604		16.0
	Carnegie				Colorado			
1922	780.45	507	65.5	13.1	527.51	720	136.6	27.3
1923	1193.32	488	45.9	11.5	330.19	302	91.5	22.9
1924	932.30	442	48.4	16.1	742.41	211	28.7	9.6
1925	1080.96	436	41.9	20.9	855.17	61	7.2	3.6
1926	1351.89	242	17.2	17.2	571.91	16	2.8	2.8
Totals	5338.92	2115		16.0	3027.19	1310		11.2
	Illinois				Inland			
1922	1727.77	709	42.6	8.5	278.16	200	75.7	15.1
1923	2574.53	1268	51.1	12.8	574.33	155	29.5	7.4
1924	2321.93	418	18.8	6.3	675.49	106	16.7	5.6
1925	2284.10	240	10.9	5.4	707.83	71	10.4	5.2
1926	2387.96	189	8.2	8.2	794.04	79	10.7	10.7
Totals	11296.29	2824		8.3	3029.85	611		8.0
	Lackawanna				Pennsylvania			
1922	973.12	452	49.9	10.0	622.22	260	43.9	8.8
1923	507.94	637	90.8	22.7	875.06	354	41.1	10.3
1924	534.11	251	50.8	16.9	846.44	526	65.3	21.7
1925	763.54	240	36.0	18.0	1117.85	374	34.3	17.1
1926	472.74	115	24.6	24.6	1011.47	192	20.2	20.2
Totals	3551.45	1695		17.6	4473.04	1706		16.2
	Tennessee				All Mills			
1922	1275.47	3161	264.9	53.0	6728.48	7070	109.4	21.9
1923	1672.54	3060	194.5	48.6	9407.16	7619	85.8	21.4
1924	1889.77	2352	136.4	45.5	9001.93	5012	58.5	19.5
1925	2086.93	1892	96.1	48.1	10081.85	3546	36.7	18.4
1926	2292.05	790	34.6	34.6	10126.11	1709	17.2	17.2
Totals	9216.76	11255		45.4	45345.53	24956		19.6

TABLE 5—AVERAGE WEIGHTS OF RAILS COMPILED FROM TONNAGES USED IN THIS REPORT.

Mill	1922	1923	1924	1925	1926
Algoma	102.1	100.8	100.5	100.9	100.7
Bethlehem	100.6	100.5	99.1	100.7	107.8
Cambria	119.4	82.0			
Carnegie	112.2	110.8	114.8	111.9	115.1
Colorado	89.9	91.2	90.2	103.7	98.0
Dominion				101.4	101.4
Illinois	96.9	98.3	98.1	101.3	103.4
Inland	101.9	98.2	96.6	104.2	101.8
Lackawanna	98.5	90.0	99.1	100.0	105.2
Maryland			99.8	93.8	110.7
Pennsylvania	113.4	118.3	123.8	122.1	125.5
Tennessee	92.0	95.4	94.4	91.8	95.9
Average	100.3	100.1	100.9	102.9	105.4

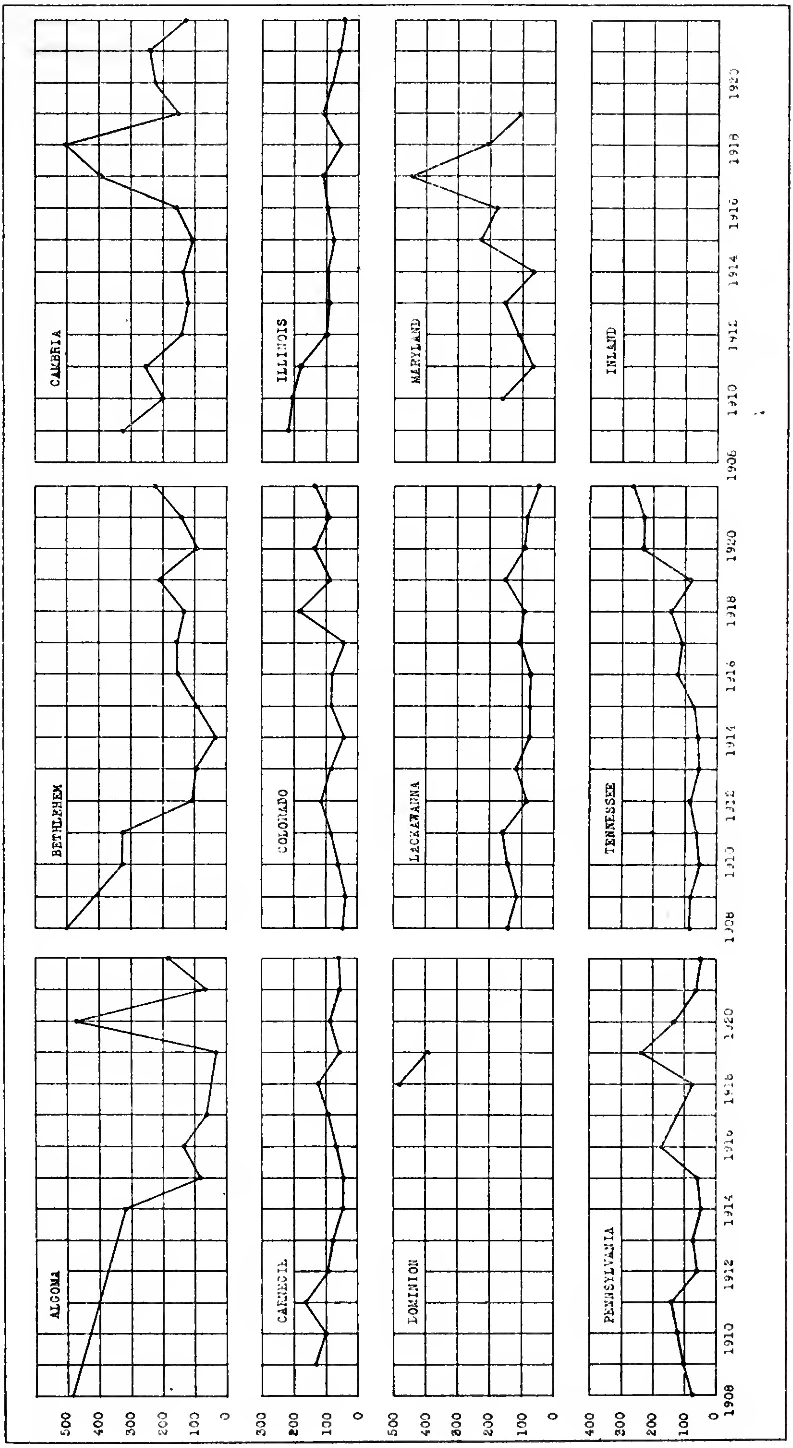


FIG. 2—RECORD OF FAILURES PER 100 TRACK MILES FOR FIVE YEARS' SERVICE FOR ROLLINGS FROM 1908 TO 1922

DIAGRAMS SHOWING MILL RATINGS FOR FIVE-YEAR PERIOD COMPILED BY USUAL METHOD.

Mill	Failures Per 100 Trk Mls. Per Year.
INLAND	8.0
ILLINOIS	8.3
COLORADO	11.2
BETHLEHEM	16.0
CARNEGIE	16.0
PENNSYLVANIA	16.2
LACKAWANNA	17.6
ALGOMA	22.6
TENNESSEE	45.4
GEN'L. AVER. ALL MILLS	19.6

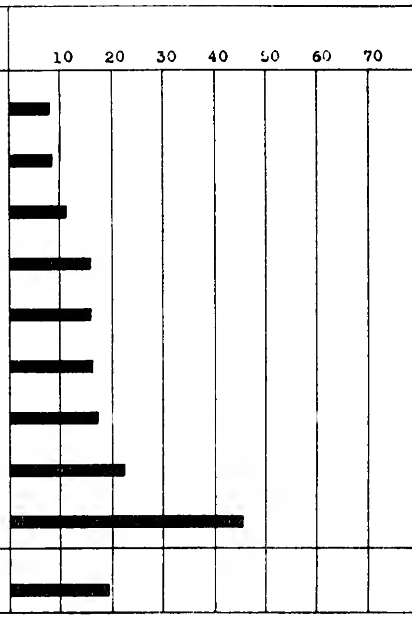


FIG. 3—AVERAGE FAILURES CLASSIFIED BY MILLS FOR THE ROLLINGS FROM 1922 TO 1926, INCLUSIVE.

DIAGRAMS SHOWING MILL RATINGS FOR FIVE-YEAR PERIOD AS ALTERED BY USE OF TRAFFIC DENSITY FACTOR.

Mill	Failures per 100 Trk Mls. Per Year Per Unit of Traffic Density
INLAND	4.0
ILLINOIS	4.9
CARNEGIE	5.7
PENNSYLVANIA	6.2
BETHLEHEM	8.0
COLORADO	9.3
LACKAWANNA	11.0
ALGOMA	22.6
TENNESSEE	32.4
GEN'L. AVER. ALL MILLS	10.9

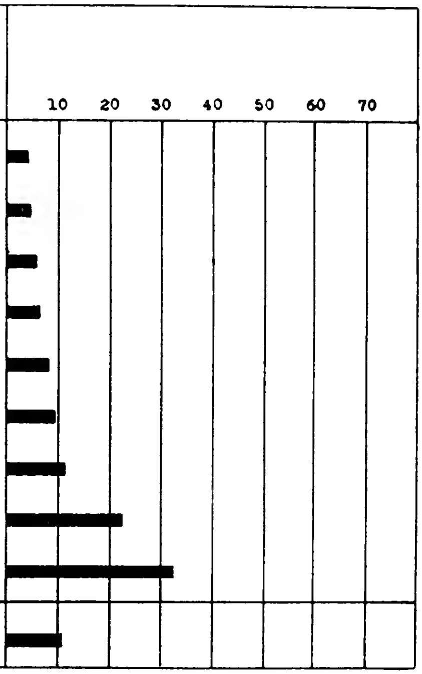


FIG 4—THIS DIAGRAM IS PRESENTED FOR INFORMATION ONLY AND SHOWS RATIOS CHANGED FROM THOSE PRESENTED IN FIG. 3.

DIAGRAM SHOWING FAILURES PER 100 TRACK MILES BY MILLS AND YEARS FOR PERIOD ENDING OCTOBER 31, 1927.

Mill	Year Rolled	Failures Per 100 Trk Mls.
ALGOMA	1922	184.4
	1923	161.8
	1924	85.7
	1925	7.9
	1926	1.2
BETHLEHEM	1922	225.4
	1923	72.0
	1924	52.0
	1925	28.2
	1926	9.0
CARNEGIE	1922	65.5
	1923	45.9
	1924	48.4
	1925	41.9
	1926	17.2
COLORADO	1922	136.6
	1923	91.5
	1924	28.7
	1925	7.2
	1926	2.8
ILLINOIS	1922	42.6
	1923	51.1
	1924	18.8
	1925	10.9
	1926	8.2
INLAND	1922	76.7
	1923	29.5
	1924	16.7
	1925	10.4
	1926	10.7
LACKAWANNA	1922	49.9
	1923	90.8
	1924	50.8
	1925	36.0
	1926	24.6
PENNSYLVANIA	1922	43.9
	1923	41.1
	1924	65.5
	1925	34.3
	1926	20.2
TENNESSEE	1922	264.9
	1923	194.5
	1924	136.4
	1925	96.1
	1926	34.6
GEN'L. AVER. ALL MILLS	1922	109.4
	1923	85.8
	1924	58.5
	1925	36.7
	1926	17.2

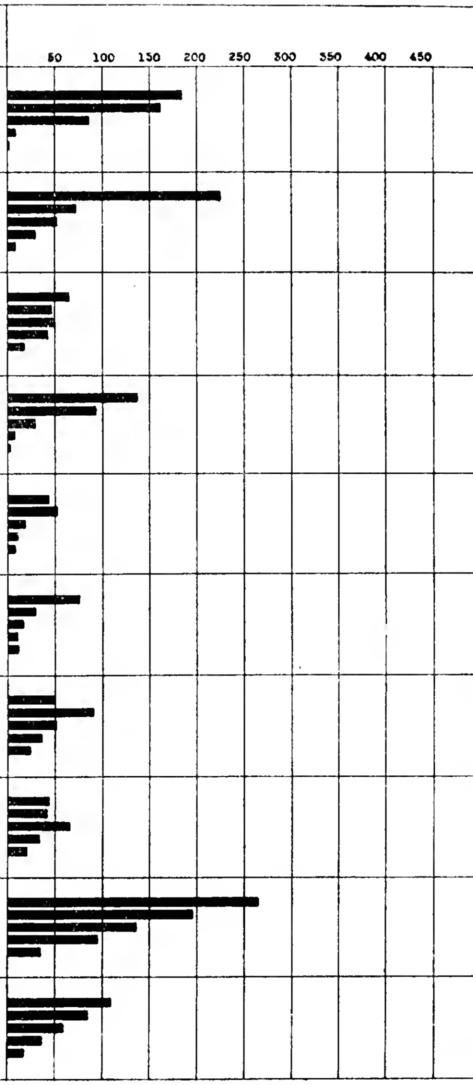


FIG. 5—ACCUMULATED FOR ROLLINGS FROM 1922 TO 1926

Appendix C

(3) TRANSVERSE FISSURE STATISTICS

By W. C. Barnes, Engineer of Tests, Rail Committee

These statistics constitute a cumulative record of 32,088 simple transverse fissure failures that have been reported up to and including January 31, 1928.

Table 1 corresponds with Table 1 of last year's report and shows the number of simple transverse fissure failures reported by each of 53 reporting roads and the years in which such failures occurred. The Pennsylvania Railroad fissure failures which occurred in the last quarter ending January 31, 1928, and which totaled 251, were reported too late for inclusion in these statistics.

The accumulated total reported to January 31, 1927, from all rollings was 27,346 and that to January 31, 1928, 32,088, or an addition during the fiscal year 1927, of 4742 fissure failures. Adding the 251 Pennsylvania Railroad failures above mentioned, the total addition for the year becomes 4993 (an average of approximately 14 per day) and the accumulated grand total 32,339.

The total of 4993 for the year 1927 exceeds the total 4596 for the year 1926 by 397, of which 151 are from the four roads not previously reporting, leaving a net increase over the year 1926 of 246 fissure failures reported from previously reporting roads.

Table 2 corresponds with Table 2 of last year's report and segregates all fissure failures accumulated from year rolled to January 31, 1928, for each year's rollings from each mill, unweighted by tonnage output of mills and by amounts of traffic carried.

This table is most useful in comparing the failures in the various rollings from any one mill.

The rollings of 1910 from all mills continue to show the maximum number of accumulated fissure failures (3166), of which total 254 were reported during the year 1927. This is mostly due to the poor record of the 1910 rolling from Illinois.

The 1913 rollings from all mills continue to be a close second with an accumulated total of 3129 failures.

The greatest number (440) of failures for all mills reported in 1927 occurred in the 1917 rollings, which are again attributed to Illinois 1917 rail. Comparison with last year's report will show that the greatest number (502) of failures reported for all mills in 1926 also occurred in 1917 rollings.

Attention is called to the marked increase in fissure failures reported during the last few years as occurring in the first year of service, as follows:

1925 rollings, all mills, 29 failures in 1925
1926 rollings, all mills, 50 failures in 1926
1927 rollings, all mills, 114 failures in 1927

Of the 114 reported in 1927 rollings, 56 were in Tennessee rail.

Table 3 corresponds with Table 3 of last year's report and gives for each mill the rate of total transverse fissure failures of 31 selected roads accumulated to January 31, 1928, per 10,000 tons of rail reported on, by years rolled. This comparison includes a total of 25,540 fissure failures and the ranking of the mills is not appreciably changed from that shown in last year's report.

Table 4 classifies the accumulated transverse fissure failures by rail and by weight of section, by mills. A slight change in manner of presentation has been made this year, in that the number of failures reported in rail of any given rail letter or weight of section, is presented in per cent of the total failures of which the rail letters or weights are known.

It will be seen that for all mills a slight majority of the fissure failures have occurred in the "A" rails, which is due to a rather marked effect of "A" rail from Illinois and from Lackawanna. In other mills, as for instance Maryland, the position of the rail in the ingot appears to have little or no effect, while in the case of Inland, the bulk of the failures occur in rails low down in the ingot.

The month rolled was reported for 4145 of the fissure failures occurring in 1927. In Table 5, these 4145 failures are so segregated and presented as to show for each mill the percentage of the total failures which occurred in the rollings of each month, unweighted by the tonnage output of mills by months.

It will be seen that for "all mills" the greatest proportion of the failures occurred in rail rolled during the winter months, the worst month being January. For the individual mills, however, the bulk of the failures is not confined to any one month, but occurs in January, February, March, April, November or December, as indicated in the table. In general, the minimum percentage of failures occurred in the month of May to October, inclusive. The irregular variation in the output by months from the various mills, from year to year, precludes the drawing of any definite conclusion from Table 5.

The following roads started reporting this year:

Central Railroad of New Jersey
Great Northern
New York, Ontario & Western
Temiskaming & Northern Ontario

ABLE 1—TRANSVERSE FISSURE FAILURES BY RAILROADS AND YEAR FAILED. (REPORT YEAR ENDS WITH JANUARY 31 OF FOLLOWING CALENDAR YEAR.)

ilroad	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	Total	1927	Grand Total
T. & S.F.			1		. 1	6	19	13	25	177	220	134	126	81	79	71	953	98	1051
C.L.																11	11	9	20
n. & Aroos.																11	11	2	13
C. & A.														0	0	0	0	0	0
ston & Albany					2	1		1	17	23	30	25	15	10	9	3	136	12	148
ston & Maine													35	69	72	78	254	70	324
& O.													212	297	369	253	1131	458	1589
. & P.												9	11	9	16	15	60	17	77
n. Nat.																13	13	-	13
n. Pac.									4		8	16	59	86	158	277	608	174	782
nt. of Ga.						3	51	52	52	23	41	31	29	24	40	20	366	20	386
n. R.R.of N.J.														.				34	34
& E.I.																4	4	-	4
& O.											6	26	46	49	81	208	389	104	493
& N.W.																85	85	63	148
B. & Q.									1	7	34	101	87	-	-	-	230	-	230
M. & St.P.								2		6	5	14	11	11	13	5	67	9	76
R.I. & P.					1	2	6	1	2	11	25	37	75	73	114	98	445	97	542
C.C. & St.L.												2	1	1	47	21	72	11	83
L. & W.		17	20	20	32	76	112	197	193	240	169	91	80	73	113	128	1561	86	1647
Paso & S.W.												8	6	(See	Sou.	Pac.)	14		14
is												15	43	89	100	118	365	148	513
eat Northern																		58	58
cking Valley												13	53	82	38	2	188	4	192
linois Central	1	1				2	3	4	35	121	190	372	556	419	501	614	2819	658	3477
d. Harbor												1	3	3	0	0	7	0	7
high & Hudson			.								1		4	4	16	33	58	10	68
& N.E.													32	0	0	0	32	0	32
high Valley												57	89	113	92	75	426	75	501
ng Island											2	8	7	11	2	3	33	6	39
A. & S.L.														1	7	12	20	36	56
& N.					(Prior	to	1919	--474)	9	17	33	43	77	90	75	141	959	295	1254
ch. Cent.													2	5	11	15	31	10	41
K. & T.											2	11	13	17	29	26	98	33	131
. Pac.												2	8	-	-	-	10	-	10
bile & Ohio																18	18	30	48
C. & St. L.				2	3	1	4			1	2	2	8	5	7	3	38	15	53
Y.C. (East)			4	43	76	124	101	67	84	88	93	136	107	126	165	223	1437	257	1694
Y.C. (West)										1	18	37	16	31	62	49	214	44	258
Y.C. & St.L.													2	-	-	-	2	-	2
Y.N.H. & H.												12	28	26	57	63	186	34	220
Y.O. & W.																		59	59
r. & Western												3	17	45	29	18	112	16	128
r. Pacific												42	39	120	161	152	514	184	698
nna.*				65	370	532	550	727	1114	1129	1104	904	649	501	785	868	9298	490	9788
ading												52	112	107	91	36	398	42	440
F. & P.																0	0	0	0
tland														-	3	2	5	1	6
. Pac.		15	4	6	11	15	4	2	9	6	130	118	143	175	243	335	1216	397	1613
. Ry.													24	6	13	51	94	123	217
m.& Nor. Ont.																		0	0
ion Pacific											36	262	557	498	473	356	2152	289	2471
stern Md.															65	111	176	164	340
l Roads	1	33	29	136	496	762	850	1540	1545	1850	2149	2584	3382	3257	4136	4596	27346	4742	32088

Penna. report for last quarter, covering 251 fissure failures, not received in time for inclusion.

TABLE 2—ACCUMULATED SIMPLE TRANSVERSE FISSURE FAILURES REPORTED TO JANUARY 31, 1928, BY YEAR ROLLED AND BY MILLS.

	Unknown			Algoma			Bethlehem			Cambria			Carnegie			Colorado			Dominion			German		
Year	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total
Unk.	27	6	33	8		8	15	3	18	16	6	22	17	5	22	16	18	34	2		2			
1889																								
1890																								
1891													1		1									
1892										2		2												
1893										1		1												
1894										6		6												
1895										5		5	1		1									
1896																								
1897										10		10	5		5									
1898										15		15	4		4									
1899										14		14	7		7									
1900										15		15	7		7									
1901										25	1	26	16		16									
1902							2		2	61		61	32	1	33	1		1				2		2
1903										57		57	61		61									
1904		4	4							22	2	24	38		38	1		1						
1905				2	2	4				26	1	27	32	1	33							2		2
1906							2		2	64	1	65	41	1	42				3	2	5			
1907				2		2	10		10	69		69	25	2	27	2		2						
1908				3	1	4	194	4	198	14		14				1		1	35	14	49			
1909				3		3	1181	58	1239	75		75	16	6	22	3		3	3	2	5			
1910	9		9	3	1	4	486	49	535	104		104	8	3	11	318		318						
1911				7	1	8	729	58	787	340	4	344	50		50	208	44	252						
1912	6		6	2	1	3	97	12	109	474	39	513	37	6	43	46	2	48	34	14	48			
1913	5	1	6	5		5	218	34	252	446	27	473	41	4	45	16	3	19	1		1			
1914	2		2	15	5	20	132	4	136	281	18	299	23	1	24	28	9	37						
1915	1	1	2	235	61	296	242	11	253	114	6	120	18	3	21	156	10	166						
1916	1		1	74	10	84	290	32	322	68	7	75	49	13	62	226	50	276						
1917	1		1	5	1	6	152	55	207	112	9	121	44	4	48	109	59	168						
1918		1	1	327	26	353	50	9	59	62	5	67	48	7	55	25	4	29	39	22	61			
1919				276	36	312	171	28	199	7		7	13	1	14	10	2	12	16	17	33			
1920				49	15	64	25	18	43	49	6	55	51	12	63	51	41	92						
1921				2	3	5	103	29	132	95	15	110	63	18	81	26	9	35	2		2			
1922				3	5	8	25	18	43	40	13	53	91	29	120	1	6	7						
1923				3	3	6	42	21	63	27	5	32	34	21	55	3	10	13						
1924				1	1	2	22	11	33	1		1	21	16	37	2	6	8						
1925					1	1	12	13	25				9	22	31									
1926							1	4	5				9	72	81							1		1
1927		2	2											9	9									
Totals	52	15	67	1025	173	1198	4201	471	4672	2717	165	2882	912	257	1169	1249	273	1522	136	71	206	5		5

TABLE 2—(CONCLUDED)—ACCUMULATED SIMPLE TRANSVERSE FISSURE FAILURES REPORTED TO JANUARY 31, 1928, BY YEAR ROLLED AND BY MILLS.

Year	Illinois			Inland			Lackawanna			Lorain			Maryland			Pennsylvania			Tennessee			All Mills		
	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total	Prior	1927	Total
Unk.	109	5	114		1	1	16	1	17				2	2	4	2		2	20	25	45	250	72	322
1889																2		2				2		2
1890							2		2							5		5				7		7
1891							4		4							3		3				8		8
1892													1		1	2		2				5		5
1893													2	1	3							3	1	4
1894													1		1	3		3				10		10
1895							1		1							2		2				9		9
1896	1		1				4		4							3		3	1		1	9		9
1897							9		9				1		1	7		7				32		32
1898							21		21				1		1	7		7				48		48
1899							12		12				3		3	18		18				54		54
1900	1	1	2										6		6	11		11				40	1	41
1901	2		2				19		19				11		11							73	1	74
1902	1		1				2		2				33		33							134	1	135
1903	1		1										48	1	49				25		25	192	1	193
1904		1	1				16	18	34				18		18				189	6	195	284	31	315
1905	6		6				9	2	11	2	1	3	26	1	27	5		5	322		322	432	8	440
1906	4		4				2	4	6	5		5	49	1	50	1		1	50	1	51	221	10	231
1907	22		22				20	1	21				74	2	76				60		60	284	5	269
1908	1	1	2				4	2	6	1		1	2		2	1		1	32		32	288	22	310
1909	418	111	529				60	3	63				53	2	55	95	3	98	5	1	6	1912	186	2098
1910	1587	156	1743				104	13	117				92	7	99	109	2	111	92	23	115	2912	254	3166
1911	196	19	215				316	8	324				189	9	198	108	1	109	132	9	141	2275	153	2428
1912	885	149	1034				749	24	773				138	6	144	35	10	45	81	12	93	2564	275	2839
1913	942	150	1092				656	60	716	1		1	357	19	376	64	5	69	69	5	74	2821	308	3129
1914	185	54	239				592	50	642				121	4	125	108	1	109	141	18	159	1628	164	1792
1915	315	61	376				239	35	274				379	11	390	174	5	179	56	9	65	1889	213	2102
1916	448	95	543				78	10	88				311	36	347	17	11	28	167	22	[illegible]	1729	287	2016
1917	1175	194	1369				88	19	107				511	70	561	1	1	2	105	28	133	2303	440	2743
1918	248	44	292				82	12	94				62	11	73	10		10	169	50	219	1122	191	1313
1919	437	143	580				40	11	51				23	7	30	66	11	77	136	79	215	1195	335	1530
1920	291	68	359				57	33	90							111	10	121	62	31	93	746	234	980
1921	118	59	177				48	17	65							75	36	111	39	20	59	571	206	777
1922	40	28	68	73	25	98	33	21	54				1	1	2	16	14	30	117	54	171	440	214	654
1923	60	86	146	6	12	18	136	61	197							37	21	58	86	39	125	434	279	713
1924	39	31	70	10	7	17	18	20	38				2		2	47	32	79	37	56	93	200	180	380
1925	11	17	28	5	10	15	20	10	30				16	14	30	19	37	56	58	123	181	150	247	397
1926	7	16	23	1	37	38	5	10	15				2	17	19	2	13	15	22	140	162	50	309	359
1927		22	22					4	4					19	19		2	2		56	56		114	114
Total	7550	1511	9061	95	92	187	3462	449	3911	9	1	10	2535	241	2776	1126	215	1341	2273	808	3081	27346	4742	32088

Table 3—Rate of Accumulated Transverse Fissure Failures on Selected Roads from Year Rolled to January 31, 1928, by Mill and Year Rolled. Basis of Rating Is the Number of Fissures per 10,000 Tons of Rail Produced for Reporting Roads. A Total of 25,540 Fissures Reported in 13,479,780 Tons of Rail by 31 Railroads, Are Included.

Year Rolled	Beth	Camb	Carn	Colo	Ill	Inl'd	Lack	Mary	Penn	Tenn	All Mills
1909	240.3	20.6	2.4	0.9	17.2		11.0	9.2	24.2	0.9	27.4
1910	79.0	20.4	1.3	33.0	53.6		7.4	13.8	16.4	12.5	30.5
1911	114.2	57.8	5.5	36.8	11.0		36.1	28.5	22.0	21.2	33.2
1912	13.3	58.3	5.4	7.7	39.0		62.6	42.8	5.0	7.7	30.8
1913	23.0	52.6	3.0	2.5	41.3		44.2	40.1	7.3	6.3	27.3
1914	21.1	47.6	3.5	4.9	23.3		61.5	43.2	19.2	9.1	24.2
1915	49.0	20.3	1.3	19.8	18.5		29.7	108.9	28.5	8.2	22.5
1916	50.0	11.3	4.9	37.8	21.9		6.6	36.7	31.7	21.5	21.6
1917	16.9	19.7	4.9	18.1	61.0		8.7	134.7	-	7.9	29.0
1918	9.0	22.1	5.5	6.3	11.2		9.4	23.8	14.7	23.4	12.3
1919	19.2	23.8	1.7	2.0	31.2		7.6	9.8	48.3	17.6	17.7
1920	8.6	20.4	4.9	11.5	12.9		5.3	0.0	24.6	8.4	10.1
1921	12.0	26.4	5.7	4.1	5.1		9.3	-	40.7	4.1	7.8
1922	9.6	11.5	11.3	0.4	3.3	17.7	4.2	-	3.7	9.1	7.0
1923	3.2	6.9	3.0	1.8	6.1	2.7	26.6	-	2.9	11.6	6.4
1924	6.0	-	2.3	0.3	2.9	2.3	4.0	-	4.9	4.8	3.4
Aver.	34.9	31.8	4.1	12.9	22.6	6.8	21.6	40.2	12.7	10.1	18.9

Table 4—Total Fissure Failures Reported to January 31, 1928, All Rollings, Segregated as to Mill, Rail Letter and Weight of Section. (Unknown Mills, German and Lorain Not Included.)

Mill		Fissure Failures by Month Rolled in Percent of Total Failures of Known Months Rollings												Total 1927 Fissure Failures		
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Kwn. Mo.	Unkwn. Mo.	Total
Algoma	Totals													172	1	173
	%	(18.6)	2.9	12.2	9.3	6.4	1.7	1.7	8.2	2.3	16.3	5.8	14.6	100		
Bethlehem	Totals													394	77	471
	%	9.9	8.3	9.9	(14.9)	4.8	4.6	5.8	1.8	7.6	8.9	12.1	11.4	100		
Cambria	Totals													132	33	165
	%	3.8	12.1	(23.5)	5.3	5.3	9.9	6.8	8.3	9.1	5.3	9.1	1.5	100		
Carnegie	Totals													231	26	257
	%	5.2	9.1	10.8	4.7	6.1	2.6	3.9	3.4	4.7	6.5	(33.3)	9.7	100		
Colorado	Totals													210	63	273
	%	10.9	10.0	7.1	5.7	6.7	6.2	8.6	10.0	8.6	8.1	(11.9)	6.2	100		
Dominion	Totals													71	0	71
	%	5.6	(36.6)	2.8	7.1	15.5	1.4	0	0	19.7	2.8	1.4	7.1	100		
Illinois	Totals													1299	212	1511
	%	13.5	9.0	7.2	5.0	4.9	3.5	5.2	5.9	9.5	10.9	11.6	(13.8)	100		
Inland	Totals													86	6	92
	%	5.8	(29.1)	1.2	5.8	4.6	3.5	10.5	11.7	2.3	2.3	2.3	20.9	100		
Lacka.	Totals													413	36	449
	%	(19.3)	12.3	6.6	3.4	5.3	4.4	4.6	2.7	6.3	6.3	12.1	16.7	100		
Maryland	Totals													200	41	241
	%	(18.0)	5.0	7.0	15.5	15.5	9.0	11.0	3.0	1.5	3.5	5.5	5.5	100		
Penna.	Totals													194	21	215
	%	8.8	6.7	11.4	(16.5)	16.0	1.0	4.6	0.5	2.6	14.9	9.8	7.2	100		
Tenn.	Totals													743	65	808
	%	11.5	13.3	10.6	10.0	5.9	7.8	5.0	3.9	3.4	4.6	9.7	(14.3)	100		
All Mills	Totals													4145	581	4726
	%	(12.4)	10.5	8.9	8.0	6.5	4.8	5.5	4.7	6.6	8.3	11.5	12.3	100		

Note - 251 Fissure failures in last quarter on Penna. R.R. not received in time for inclusion.

TABLE 5—1927 FISSURE FAILURES FROM ALL ROLLINGS SEGREGATED AS TO MILL AND MONTH ROLLED. (UNKNOWN MILLS, GERMAN AND LORAIN NOT INCLUDED.)

Mill		Fissure Failures by Rail Letter in percent of Total "Kwn. Letters" A	B	C	D	E	Lower	Total Fissure Failures Kwn. Letters	Unkwn. Letters	Grand Total	Fissure Failures by Weight of Section in percent of total "Kwn. Weights" 61-70	71-80	81-90	91-100	101-110	111-120	121-130	131-up	Total Fissure Failures Kwn. Weights	Unkwn. Weights
Algoma	Totals							890	303	1198									1048	150
	%	17.5	16.4	(19.2)	17.6	16.4	12.8	100				0.7	78.1	19.1	0.6	1.5			100	
Bethlehem	Totals							2840	1832	4672									2912	1760
	%	15.9	(22.2)	19.4	20.4	10.3	12.0	100				0.8	14.8	51.7	13.9	0.1	10.3	8.4	100	
Cambria	Totals							1175	1707	2882									1647	1235
	%	(23.6)	22.7	19.2	19.2	7.8	7.5	100				0.4	5.2	71.7			22.7		100	
Carnegie	Totals							689	480	1169									889	280
	%	16.0	(21.0)	20.5	18.9	13.8	9.8	100			0.1	3.3	13.0	62.3	0.4	0.1	20.8		100	
Colorado	Totals							1335	187	1522									1340	182
	%	(26.2)	24.0	19.8	18.3	5.0	6.8	100			0.1	32.1	59.6	8.2					100	
Dominion	Totals							151	55	206									206	0
	%	11.9	19.9	(21.8)	18.5	17.2	10.6	100			0.5	15.5	83.0	1.0					100	
Illinois	Totals							7242	1819	9061									7267	1794
	%	(31.6)	15.2	17.9	10.1	8.3	17.0	100				0.3	62.7	34.2	2.5	0.1	0.2		100	
Inland	Totals							170	17	187									145	42
	%	16.5	11.2	8.8	15.3	12.9	(35.3)	100					85.0	8.2	4.7		2.1		100	
Lacka.	Totals							2825	1086	3911									3012	899
	%	(42.4)	27.6	18.3	9.8	0.9	1.0	100			0.2	8.5	3.2	21.6	65.7		0.8		100	
Maryland	Totals							1639	1137	2776									1777	999
	%	22.8	20.0	19.3	(23.0)	8.8	6.2	100				0.7	7.9	60.9	3.3		27.2		100	
Penna.	Totals							797	544	1341									927	414
	%	21.5	16.6	16.5	14.6	6.8	(24.2)	100				0.3	5.5	58.6	10.1	2.1	23.2	0.2	100	
Tenn.	Totals							1853	1228	3081									2148	933
	%	24.1	(24.3)	12.1	10.9	9.5	19.1	100				13.6	68.3	17.1	1.0				100	
All Mills	Totals							21606	10400	32006									23318	8688
	%	(27.1)	20.1	18.0	14.3	8.1	12.4	100				4.8	38.0	37.2	11.8	0.2	6.9	1.1	100	

Note - 251 Fissure failures in last quarter on Penna. R.R. not received in time for inclusion.

Appendix D

(4) CAUSE AND PREVENTION OF RAIL BATTER

W. J. Backes, Chairman, Sub-Committee; L. C. Fritch, E. A. Hadley, C. W. Johns, Hunter McDonald, R. Montfort, W. H. Penfield, G. A. Phillips, J. E. Willoughby, W. P. Wiltsee, W. C. Barnes.

This report is presented to stimulate interest on the part of the various railroads so that sufficient data may be obtained to make the final results of value to all.

The cause and prevention of rail batter requires extensive investigation for a complete answer and though individual cases show the opposite, if the same general trend is found in the batter of rail of three years' service and thirteen years' service; of low tonnage and high tonnage; of good maintenance and under maintenance; of one railroad and another, it is a fair assumption that this trend is real.

Further investigation by this Sub-Committee has developed these additional causes of batter:

(1) Differences in Elevation of Top Surfaces of Rail

Theoretically, the top surface of rail in track should be perfectly straight and in the same plane longitudinally, so that there would be no break in the continuity of motion of a wheel passing over it, except at the joint gap. Batter implies its nature by its name and must be either the result of abrasion or impact. As only engine drivers would tend to abrade (except on brake applications and curves) batter must be the result of impact.

A considerable number of joints do not develop batter to a serious extent even though tens and hundreds of million gross tons pass over them. We, therefore, find what may be called the tonnage influence. Though in itself it does not start or cause batter, there can be no batter without it, and when once batter has started it immediately makes matters worse and continues to do so until the condition has been remedied or the rail renewed.

It is interesting to note on Graph 3 that apparently the minimum batter would obtain if the leaving rail was five thousandths of an inch higher than the receiving rail. This appears to be the ideal condition with the present joint construction.

(2) Difference in Rail and Splice Bar Contour at the Fishing Space

When the fishing space on one rail end is slightly larger than the corresponding space on the other rail at the joint, the application of a splice bar, which is subject to considerable variation also, will only fit the rail with the smaller fishing space. The other rail will be loose to the extent of the excess in this space. Thus though two rail ends at a joint appear to be of the same height, when a train passes over the joint a leaving high or receiving high condition is brought about due to the looseness of the one rail end with respect to the other. When this condition exists, batter will develop in the same manner as would rails of an actual difference in height, equal to the amount of looseness at the joint.

(3) Joint Gap

Excessive joint gaps undoubtedly tend to increase batter. On the Boston & Maine Railroad, however, as indicated on Graph 4, if this joint gap is kept at ⅜ inch or less the various other factors which cause or influence batter practically obliterate the joint gap influence.

(4) Under Maintenance in One or More of Its Various Types

The fact that excessive batter occurs in track where joint maintenance is neglected is generally recognized by maintenance men. However, to further establish this a series of readings were taken on the Boston & Maine Railroad which consisted of 50 and 30 consecutive joints at two locations, where ordinary maintenance obtained, and 50 consecutive joints at one location where a special effort was made to insure as nearly perfect maintenance as could reasonably be obtained. The rail and track structure in each location was uniform.

Readings were taken at each location every day for the first few days after the rail was laid, then once or twice a week for seven weeks. The results are plotted on Graph 1 and indicate that batter can be reduced by improving the maintenance condition.

As has been stated above, tonnage is considered as an influence and not a cause. There are various other influences which tend to increase the amount of batter under given conditions when they are present. These are curvature, grade and low carbon content or variations in manufacture.

The means of preventing batter completely have not as yet been found. The general direction which further improvement must take is all that can be brought forth at this time. The reduction of batter will be found mainly in the improvement of the rail joint and rail manufacture. In many instances an improvement in maintenance would undoubtedly lessen batter to a great extent and along this line will be found the more immediate relief. A third means of prevention of batter would be to increase, through special processes, the resistance of the rail steel to the higher impacts resulting from the recent increase in wheel loads.

It is our opinion, however, that to increase the rail strength and improve the maintenance conditions, without greatly improving the present rail joint would not greatly improve present conditions.

There are two figures which have proved to be general with respect to all rail in track operated in one direction:

(1) The percentage of difference in rail end conditions, shown elsewhere in this report, of 50 per cent leaving high and 30 per cent even and 20 per cent receiving high, thus proving that 70 per cent of rail ends have sufficient difference in end elevation to cause batter.

(2) The 60-40 ratio of batter between the receiving and the leaving

rail as indicated in Table 1. This ratio does not hold true in all cases, but a general average indicates that it usually obtains. A variation in this ratio can usually be explained by a study of local conditions.

The Causes of Rail Batter May Be Summarized as Follows:

Under-maintenance in one or more of its various types.
Difference in elevation of top surfaces of rail.
Differences in rail and joint contours at the fishing space.
Variations in rail steel due to mill practice.
Joint gap to a slight degree.

Factors of a Contributory Nature Whose Effect Is Felt When Present Are:

Tonnage (which is always present).
Curvature.
Grade.
Low carbon content.

The prevention of batter will be found along the lines of joint design, maintenance and quality and manufacture of rails.

Spraying Rails and Joints With Molten Metal—Tests on Boston and Maine Railroad

This process, called "Metalayer," has been applied on rails, joints, tie plates, abrasion plates, bolts and nuts. It consists of sand-blasting, to clean and roughen the steel, and then spraying with molten zinc, aluminum, lead, tin, copper or monel, as the case may be. The bond between the sprayed metal and the steel is purely mechanical and if proper sand-blasting is done, the coating is attached firmly enough to allow of machining if necessary.

After three months, tests indicated a perfect bond through the joint for propulsion of current. Four joints in automatic signal territory have been unbonded for more than a month.

The cost of this treatment is high and considerable improvement in joint and bond conditions will have to obtain to justify the added cost.

1926 Krupp Rail Batter Readings on Boston and Maine Railroad

Comparative readings converted to hundred thousandths of an inch per month indicate that as far as batter is concerned, they are giving very good service. This may be due to the one point average higher carbon content. These rails showed a minimum of segregation between the "O" and the "M" points, but are showing a tendency to split which is as yet unexplained. These comparative readings are tabulated on Table 1.

NOTES ON TESTS MADE ON THE N. C. & ST. L. RAILWAY IN THE MATTER OF CAUSE AND PREVENTION OF RAIL BATTER

Reference is made to page 582 of Volume 29 of A.R.E.A. Proceedings for the subjects upon which Mr. McDonald promised further contributions.

Lubrication.—No new experiments have been undertaken in the matter of lubrication at joints, past experience having indicated that no advantage was to be derived from the use of oil or greases.

The elimination of frozen joints will have to be brought about either by securing uniformity of bolt tension, not in excess of that required to develop the full strength of the joint and in connection with adequate rail anchorage, or through the "Metalayer" process of spraying the fishing surfaces involved, with molten metal. This process is described elsewhere in this report.

It is essential, however, that some method be devised to prevent the rusting of bolts and joint and rail surfaces which are concealed by the joint bars. The plan of wiping the ends of new rail being laid with heavy asphaltic oil, as now pursued by some roads, should prove of benefit. The joint bars and bolts should be similarly treated. Oil applied to the sawed surfaces of the ends of the rail will facilitate the removal of expansion shims under pressure. Some method of spraying heavy oil behind the joint bars of rail already in the track should also be developed.

Observations on Atlanta Division.—Opposite page 582 of Volume 29 will be found the form used for recording observations taken to determine the relative rate of battering of high and low carbon rails.

Exhibits 2 and 3, appearing on pages 583 and 585, respectively, of Volume 29, have been brought up to date and are re-submitted. The slightly increasing superiority of the high carbon rails in resistance to battering continues to be shown.

Effect of Tie Arrangement With Respect to Joint.—Reference is made to Exhibit "O," page 591, and Exhibit "P," page 592, of Volume 29. During the year it was found necessary to reballast a considerable portion of mile 106, Chattanooga Division, upon which tests have been carried out. Some ties were respaced. The number and location are not available at this time. No report will, therefore, be made for this year. However, there are enough joints where the ties have not been disturbed since the rail was laid in 1923 to render further study possible.

Exhibit I shows in solid lines the average head fishing wear of joints measured in thousandths of an inch with a taper gage on September 15, 1928. It also shows in dotted lines the same measurements taken September 15, 1927. It will be noted that the trend of the two curves is comparatively regular, but the results for 1928 show generally less wear than for 1927.

The two sets of observations were made by the same observer and in the same manner, the joint being jacked up in every case. The measurements, of course, include tolerance. The only way in which the condition presented by the exhibit can be accounted for is either that the tension of the bolts had been increased in advance of the last observation or that rust had frozen more joints. No general tightening of bolts was carried out.

The rusting of the bottom surface of the joint bar and the top surface of the base of rail takes place more rapidly than at the top. This bottom rusting would tend to press the joint bar upward and possibly inward, which in either case would reduce the head fishing wear. The results shown on the exhibit demonstrate the unreliability of this method of measuring so long as there is any possibility for take-up. Probably the only method which will give accurate results would be to remove the joint bars and plot the contours of the joints and rail but this would be a tedious and expensive process. Another observation will be reported for 1929 and the report will include joint gaps and broken joints.

Battering.—On Exhibit "O," page 591 et seq., of Volume 29, the welding up of rail ends which had taken place up to September 15, 1927, was shown. It also shows the batter and head fishing wear which had taken place up to that date.

In our early welding work, the rod used proved too soft and it became necessary in a number of instances to weld some of the joints a second time. A better welding rod was used at a later date. All of the initial welding was brought about either by softness of the rail or by chipping. Much of the secondary welding was due to softness of the underlying rail steel.

While a statement similar to Exhibit "O" has been made up from observations taken September 15, 1928, it is not considered advisable to burden the Proceedings with its publication. It shows that 35.7 per cent of the total rail ends have been welded once, while 8.7 per cent have been welded twice.

Our records do not show whether welding was made necessary by chipping or by batter. Neither is it practicable to arrive at a reliable figure of the total batter at any welded joint. On account of the above conditions, no further measurements of the batter on this mile for the Committee will be made but percentages of joints welded will be reported as above.

Sawing Off End Overflow.—Some inquiries have been made of other lines as to the advantages and cost of this method of guarding against chipping but no replies have been received. This practice is of such importance as to call for careful investigation.

Sawing After Welding.—We find that it costs about thirty cents per joint to saw off welded metal projecting into the joint gap. This restores the required expansion space and tends to prevent further chipping. Removing the projecting metal with the chisel is cheaper but does not accomplish the desired result, since the chisel cut is not always even and in many instances cannot extend deep enough into the joint to remove all projecting welded metal. Further data on this subject are desirable.

The following definition was adopted at the 1927 Convention of the Association (A.R.E.A.):

BATTER.—The distance in 64ths of an inch between the bottom of a straight edge 12 inches long, applied along the top center line of the rail (with one end coinciding with the end of the rail) and the top of the rail at a point ½ inch from the end of the rail.

(A) For welding up, resawing and renewal purposes the batter should be measured with a taper gage.

(B) For statistical purposes the batter should be measured with a micrometer.

It is recommended that this be changed to read as follows:

Half Inch Point Batter.—The distance in thousands of an inch between the bottom of a straight edge 12 to 24 inches long, applied along the center line of the worn surface on the top of the rail (with one end coinciding with the end of the rail) and the top of the rail measured at a point ½ inch from the end of the rail.

End Batter.—The distance at the end of the rail measured as for half inch point batter.

Total Batter.—The sum of half inch point batter and end batter.

(A) For welding, resawing and renewal purposes half inch point batter taken with a taper gage in 64ths of an inch will be sufficient.

(B) For statistical purposes the batter should be measured with a dial micrometer in thousands of an inch. For uniformity the use of standard batter gage is recommended.

Method.—For statistical purposes standard sheets shall be used and the following seven readings included as shown:

(1) Leaving rail batter length
(2) Leaving rail half inch point batter
(3) Leaving rail end batter
(4) Receiving rail end batter
(5) Receiving rail half inch point batter
(6) Receiving rail batter length
(7) Difference in end elevation

An illustration of an instrument developed for taking batter readings and which was described at the joint sub-committee meeting in Washington on April 24, 1928, is appended hereto. It is recommended that this instrument and a 24-inch straight edge be adopted as standard.

The adoption as standard of a 24-inch straight edge with dial micrometer for taking batter measurements is recommended for two reasons:

(1) To obtain sufficient bearing on the unbattered surface of badly battered rail.

(2) To obtain a greater uniformity of results when comparing readings taken on various railroads.

Two sheets for taking batter data are also presented herewith:

(1) "A.R.E.A. Rail Batter Investigation," which completely describes the location and conditions where batter readings are to be taken.

(2) "A.R.E.A. Rail Batter Notes," which contain the actual readings. When readings are to be taken periodically, at the same location, it will only be necessary to fill in the second sheet when taking subsequent readings as the first sheet will always apply.

It is recommended that these two sheets be adopted as standard.

GRAPHIC CHARTS

Boston and Maine Railroad

1. Effect of good maintenance on early life of rail. (Note abrupt change in rate of batter about the fifth day.)

2. Effect of relative rail end elevation at joint on total batter. (Note high rail is battered more in each case and 48 per cent have more batter on leaving rail than on receiving rail.)

3. Correlation of batter and rail end elevation. The difference between the batter of the leaving and receiving rails increases as the difference in rail end elevation increases. (Note that to obtain equal batter the leaving rail must be slightly higher than the receiving rail.)

4. Effect of joint gap on batter. The influence of joint gap is very slight as large and small batter seems to occur irrespective of the joint gap.

5. Comparison of batter of high and low rail on curves. (The 3½-degree and 8½-degree curves were compensated proportionately because the tonnage was higher than the eleven million of the others.)

6. Effect of carbon content on batter. The greater the difference in carbon between the two rails at a joint the greater the batter, and the low carbon rails were battered slightly more than the high carbon rails. (Note that the difference in points carbon is plotted against the sum of the batter of the two rail ends at a joint whereas the points carbon is plotted against the sum of the batter of the two ends of one rail.)

7. Graphic cross sections of battered joints. The tonnages over this rail are Maryland, 1914, 142 million and Lackawanna, 1915, 131 million. (Note the secondary batter 8 to 10 inches from the end of the receiving rail.)

8. Relation of batter to tonnage and rail age. As tonnage and months of service increase there appears to be a decrease in batter per month or unit increase of batter. (Note the extreme high readings in a few instances.)

D. L. & W. and N. Y. C. Batter Readings

A—Leaving and receiving rail batters have been separated into the three joint condition classes which show the kind and location of batter. The B. & M. values are lower because the tonnage is lighter. The average of 2,000 joints is included to show the general similarity of batter of all tonnages and ages of rail to that found in the special cases which were picked for similarity of conditions. (The special cases are the 188 joints of the B. & M., the 271 joints of the D. L. & W. and the 302 joints of the N. Y. C.)

TABLE 1

Krupp—1926

(½-Inch in Batter Only—100,000ths of an Inch per Month)

Letter	*Lv. Rail*	*Rec. Rail*	*Rec. Rail Plus or Minus 60%*	*Remarks*
A	.00029	.00065	+ 9	Under maintenance
B	.00018	.00042	+ 10	Under maintenance
CA	.00026	.00037	— 1	Good maintenance Rock ballast
CB	.00026	.00033	— 4	Good maintenance Rock ballast
CC	.00024	.00040	+ 3	Good maintenance Rock ballast
G	.00094	.00098	— 9	— 3° curve + 1% grade
IA	.00059	.00088		Good maintenance
IB	.00056	.00092	+ 2	Good maintenance
Average	.000332	.000495		
Per Cent	40	60		

Lackawanna—1923

(½-Inch in Batter Only—100,000ths of an Inch per Month)

Letter	Lv. Rail	Rec. Rail	Rec. Rail Plus or Minus 60%	Remarks
J	.00032	.00041	— 3	High tonnage
P	.00019	.00030	+ 2	Low tonnage
TA	.00029	.00033	— 6	High ascending grade
TB	.00026	.00049	+ 7	Low tonnage descending grade
Average	.000265	.000382		
Per Cent	41	59		

Lackawanna—1925

(½-Inch in Batter Only—100,000ths of an Inch per Month)

Letter	Lv. Rail	Rec. Rail	Rec. Rail Plus or Minus 60%	Remarks
D	.00045	.00049	—10	Through yard—many reverse moves
M	.00039	.00077	+ 4	
W	.00027	.00054	+ 5	
Average	.00037	.00060		
Per Cent	38	62		

Batter Readings Taken by Sub-Committee 3 of Rail Committee and Sub-Committee of Track Committee

No.	Letter	Date	Location	Rail	Year Rolled		Tonnage, Millions	
(32)	DLW-A	6-5-28	..M. P. 8 M. & E. Div..	118	1923	MM	55	
(30)	DLW-B	6-5-28	....Kingston Tunnel....	118	1923	MM	55	
(31)	DLW-C	6-5-28	..M. P. 7 M. & E. Div..	105	1923	OHC	62	
(30)	DLW-D	6-5-28	.Mountain View Tower.	118	1925	MM	42	
(31)	DLW-E	6-5-28	.... Dover	130	1925	MM	39	
(30)	DLW-F	6-6-28	.M. P. 41 M. & E. Div.	130	1928	MM	1.7	
(30)	DLW-G	6-6-28	..Sig. 608 Johnsonburg..	118	1924	MM	69	
(30)	DLW-H	6-6-28	M. P. 72 M. & E. W. Div.	105	1921	OHC	69	
(30)	DLW-J	6-6-28	..... Stroudsburg	130	1927	MM	20	
(50)	P&R-A	6-7-28	...... Monocacy	130-RE	1924	OHC	36	HF-100%
(50)	P&R-B	6-7-28	...... Monocacy	130-RE	1924	OHC	36	HC-100%
(50)	P&R-C	6-7-28	...... Monocacy	130-RE	1924	OHC	36	HF-Cont.
(50)	P&R-D	6-7-28	...... Neversink	130-HFB	1928	OHC		HF-Cont.
(30)	NYC-A	7-10-28	..... Poughkeepsie	105	1923	OHC	150	
(30)	NYC-B	7-10-28	...71-4 Hudson Div...	105	1923	OHC	150	
(30)	NYC-C	7-10-28	...78-25 Hudson Div...	105	1924	OHC	96	
(30)	NYC-D	7-10-28	...78-29 Hudson Div...	105	1925	OHC	20	
(30)	NYC-E	7-10-28	...80-25 Hudson Div...	127	1928	OHC	1.6	
(30)	NYC-F	7-11-28	.....Br. 503-5 Utica.....	127	1926	OHC	50	
(30)	NYC-G	7-11-28	...245-18 Mohawk Div..	127	1927	OHC	20	
(30)	NYC-H	7-11-28	...254-0 Mohawk Div...	115	1923	OHC	105	
(30)	NYC-J	7-11-28	...254-0 Mohawk Div...	127	1928	OHC	..	
(32)	NYC-K	7-11-28	...257-0 Mohawk Div...	105	1923	OHC	126	

	Number of Readings	Leav. High Per Cent	Even Per Cent	Rec. High Per Cent
Boston & Maine...........	1390	47	37	16
New York Central.........	300	61	23	16
Delaware, Lackawanna & Western	270	61	22	17
Reading	200	43	35	22
Average	2160	50	33	17
Average ....(Equal Weight)		53	29	18

Delaware, Lackawanna & Western Railroad

130-Lb., 1928, Medium Manganese Rail Tangent. Joint No. 1 Is First Joint East of Electric Company Crossing Just West of 41 Working East. Readings Taken June 6, 1928.

		Batter in Thousandths				
		Leaving		Receiving		
Joint No.	*Joint Gap*	*1/2" In*	*End*	*End*	*1/2" In*	*Remarks*
1	1/8	7	16	7	7	10
2	1/8	5	14	14	10	0
3	1/4	9	21	13	10	12
4	5/32	6	17	10	8	7
5	1/4	8	19	15	10	6
6	3/32	6	14	16	10	0
7	5/32	10	19	16	10	3
8	1/8	5	15	8	4	11
9	5/32	8	19	11	7	10
10	1/8	8	16	19	14	0
11	5/32	8	18	12	7	6
12	3/32	8	15	8	5	5
13	1/8	8	16	7	5	8
14	1/4	9	19	13	10	3
15	1/16	4	11	10	7	0
16	5/32	3	13	12	9	0
17	1/4	7	15	15	10	3
18	1/4	11	20	19	11	5
19	1/4	8	18	7	5	12
20	1/4	14	23	16	10	11
21	3/8	5	13	13	8	0
22	5/16	8	17	16	9	5
23	1/4	8	17	17	10	R- 2
24	1/4	8	15	13	10	0
25	1/4	10	21	13	11	15
26	3/8	9	17	14	9	13
27	1/4	9	18	20	14	0
28	3/8	10	25	31	22	R-10
29	3/16	11	17	20	12	R- 6
30	1/4	6	16	14	10	2
	Totals	236	514	419	284	
		750		703		
		1453				

Total average per joint............ 48.43
1/2" only average per joint......... 17.33
1/2" only average per month........ 17.33

28 apparently battered from step joint connection at some time.

METHOD OF COMPUTATION

(19)

7	16	7	7
9	21	13	10
6	17	10	8
8	19	15	10
10	19	16	10
5	15	8	4
8	19	11	7
8	18	12	7
8	15	8	5
8	16	7	5
9	19	13	10
7	15	15	10
11	20	19	11
8	18	7	5
14	23	16	10
8	17	16	9
10	21	13	11
9	17	14	9
6	16	14	10
159	341	234	158
500		392	
8.4	18.0	12.3	8.4
26.4		20.7	

(8)

5	14	14	10
6	14	16	10
8	16	19	14
4	11	10	7
3	13	12	9
5	13	13	8
8	15	13	10
9	18	20	14
48	114	117	82
162		199	
6.0	14.3	14.6	10.3
20.3		24.9	

(3)*

8	17	17	10
10	25	31	22
11	17	20	12
29	59	68	44
88		112	
9.7	19.7	22.7	14.7
29.4		37.4	

159	341	234	158
48	114	117	82
29	59	68	44
236	514	419	284
750		703	
1,453			

Total average per joint	48.43
½-inch only	520
½-inch only—average per joint	17.33
½-inch only—average per month	17.33

*Total, all three groups, 30.

A.R.E.A. RAIL BATTER INVESTIGATION

Track Under Observation

Initial Date .... Railroad

Rail	*General*
Weight	Division ....
Section	Nearest Station ....
Mfgr.	Mile Post ....
Date Rolled	Track ....
Date Laid	Curvature ....
Splice Bar	Grade ....
Type	Tonnage ....Per Year
No. Holes	Alignment ....
Date Applied	Surface ....
Previous Type	Super-Elevation ....
Ballast	*Anti-Creepers*
Kind	Type ....
Depth	Number per Rail...................
Condition	Spring Washers—Type..............

REMARKS

Type of Bolt and Nut...

....

....

....

JOINTS NUMBERED IN THE DIRECTION OF TRAFFIC – ODD NUMBERED JOINTS IN THE SOUTH OR WEST RAIL. GAP IN 64ths OF AN INCH. BATTER IN 0.001 OF AN INCH. LENGTH OF BATTER NOT TO INCLUDE SECONDARY BATTER OR UNEVENESS OF THE RAIL SURFACE. DIFF. IN END ELEVATION TO BE MEASURED BEYOND END OF LOW RAIL BATTER — MINIMUM OF 3" FROM END OF RAIL. RECEIVING RAIL HIGH DISTINGUISHED BY "R" PRECEEDING AMOUNT. DIFF. TO BE MEASURED BY PLACING GAUGE ON HIGH RAIL WITH DIAL EXTENDED OVER LOW RAIL.

A. R. E. A.

RAIL BATTER NOTES

________________ R. R.

DATE __________ WEATHER __________ TEMP ______ SHEET ___ OF ___

JT. No	HEAT NO	GAP	LEAVING (EAST) RAIL BATTER			RECEIVING (WEST) RAIL BATTER			DIFF IN END ELEVATION	REMARKS
			LENGTH	½" IN	END	END	½" IN	LENGTH		
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

RAIL BATTER GAUGE

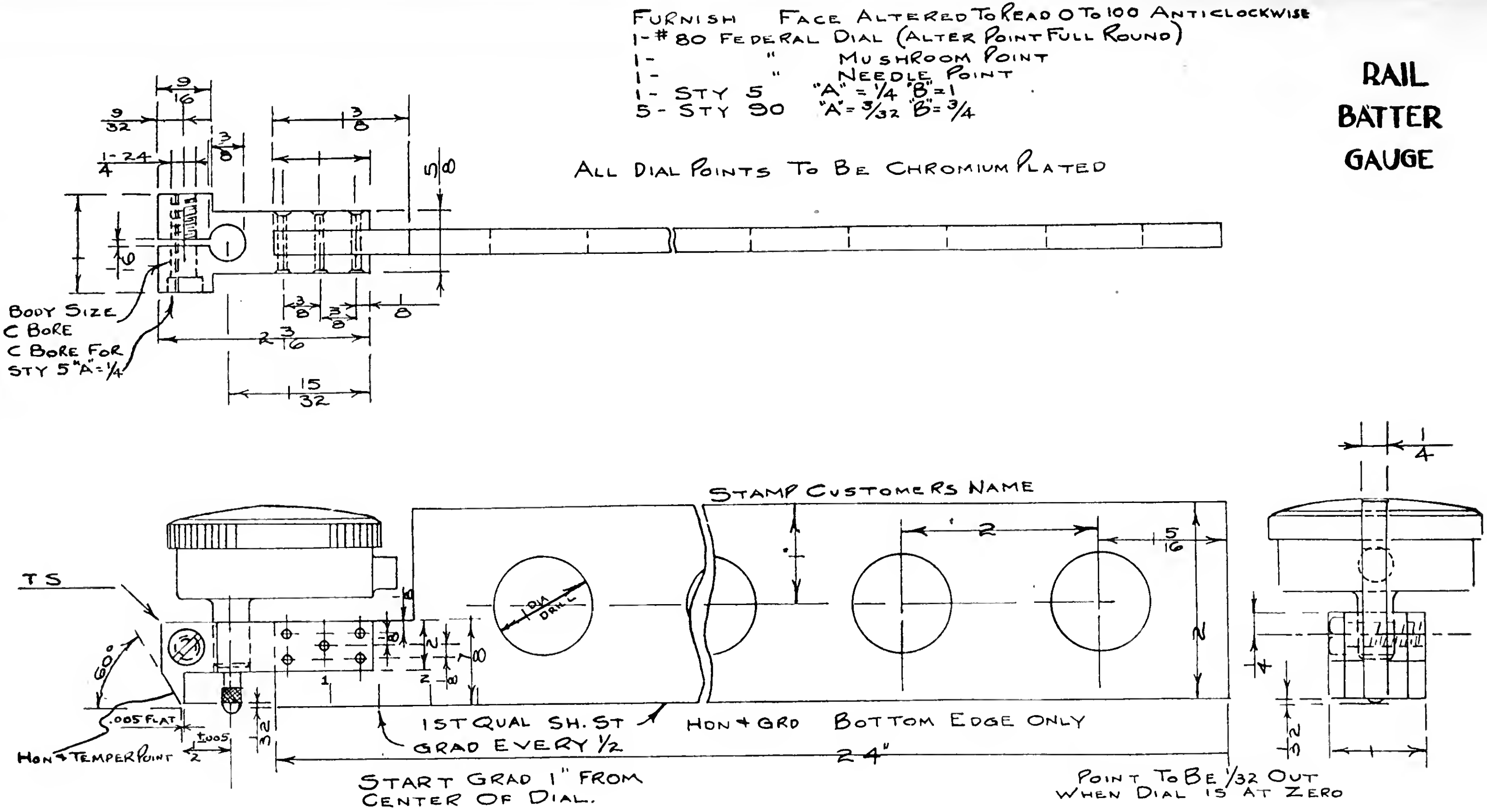


Exhibit 1

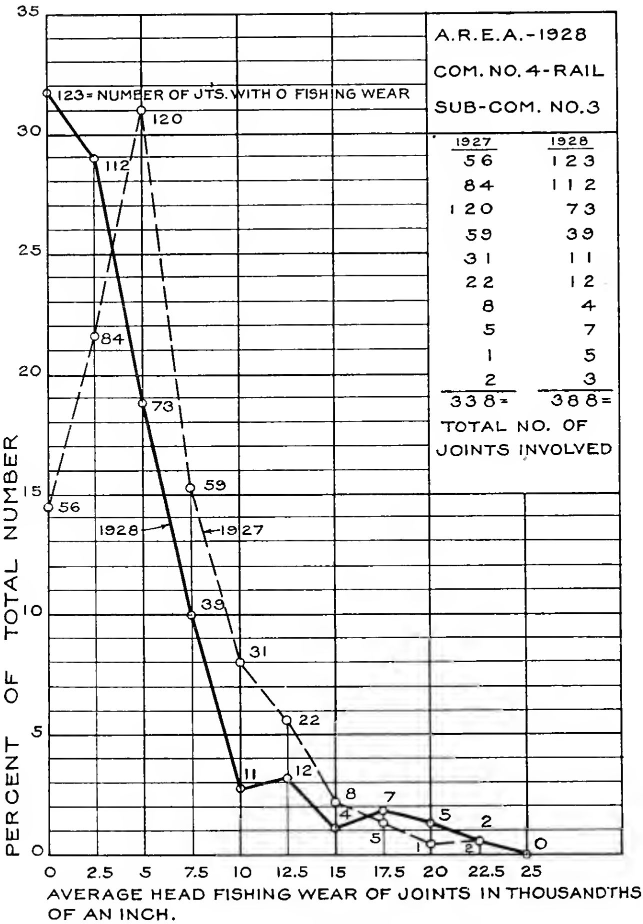
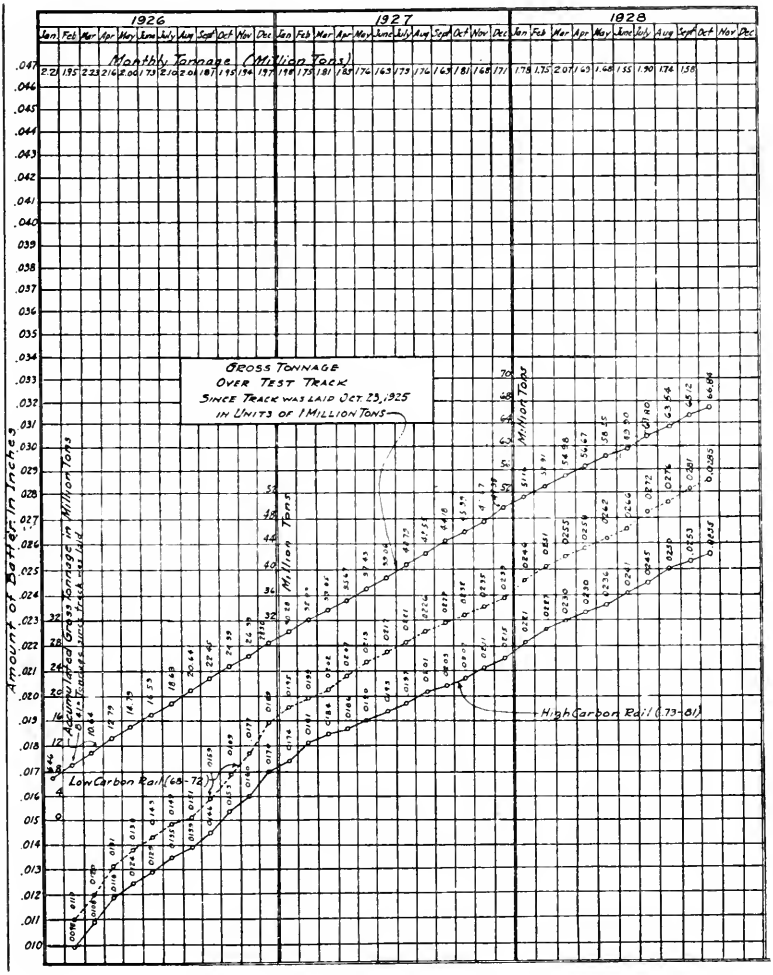


CHART SHOWING NUMBER AND PERCENT OF TOTAL OF JOINTS IN TEST TRACK, AS COMPARED TO AVERAGE FISHING WEAR OF JOINT.

ON MILE 105-106.2 CHATTANOOGA DIV. OF N.C.& ST.L.RY.
MEASUREMENTS TAKEN SEPT. 15, 1927 AND SEPT. 15, 1928

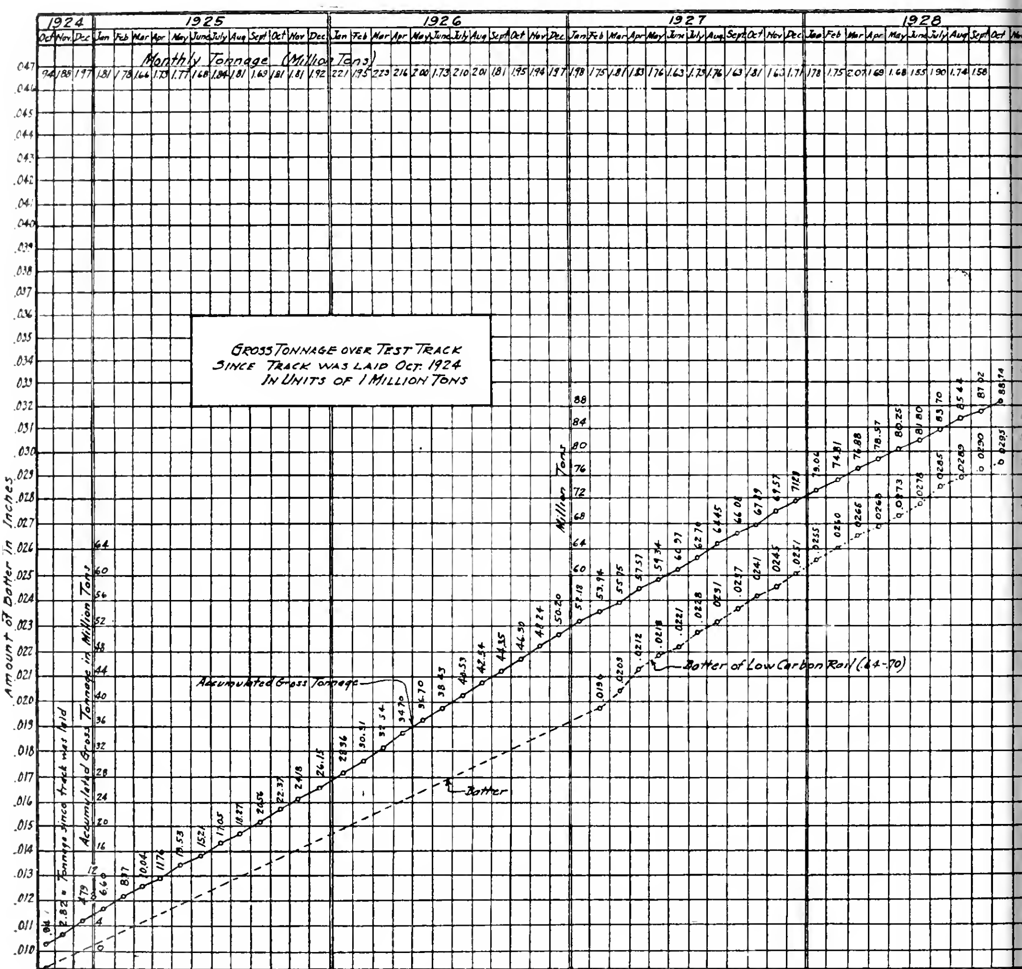
Exhibit 2



Graph of Progressive Batter for High and Low Carbon Rail. Vinings, Ga. Atlanta Division. Milepost 11.0 to 11.3. Pole 11.0½ to 11.10½.

110-lb. RE. rail. Laid October 17-23, 1925. Track tangent: Grade 0.6 per cent. Crushed stone ballast. Batter shown is the average of measurements taken at each end of each rail and is expressed in inches.

Exhibit 3



GRAPH OF PROGRESSIVE BATTER FOR LOW CARBON RAIL. MILEPOST 46.2-46.3. ATLANTA DIVISION.

Grade 0.48 per cent. Range of carbon .64 to .70, average .69. Range of manganese .68 to .80, average .76. Batter shown is the average of measurements taken at each end of each rail and is expressed in inches.

Chart 1

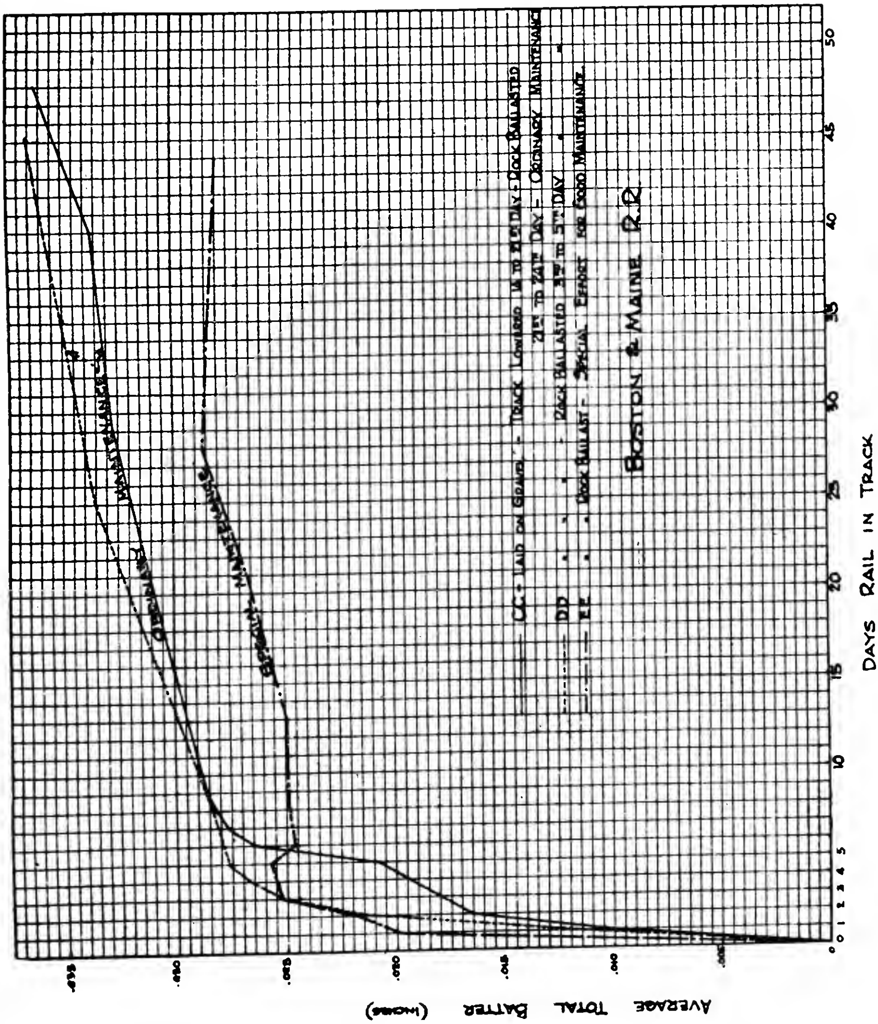

CC - Laid on Gravel - Track Lowered
Day - Rock Ballasted
21st to 24th Day - Ordinary Maintenance
DD - Rock Ballasted 3rd to 5th Day
EE - Rock Ballast - Special Effort for Good Maintenance
Boston & Maine R.R.
Ordinary Maintenance
Special Maintenance
Days Rail in Track
Average Total Batter (Inches)
0 1 2 3 4 5 10 15 20 25 30 35 40 45 50
.005 .010 .015 .020 .025 .030 .035

Chart 2

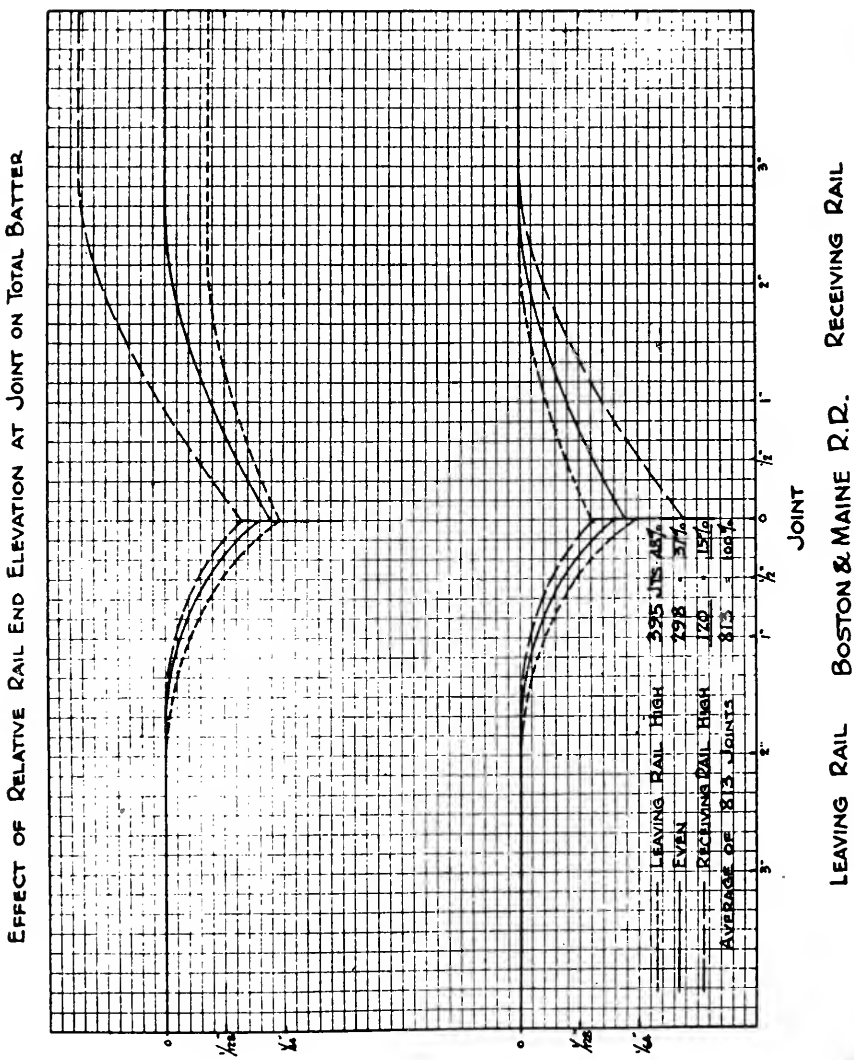

EFFECT OF RELATIVE RAIL END ELEVATION AT JOINT ON TOTAL BATTER
LEAVING RAIL HIGH 395 JTS. 48%
EVEN 298 37%
RECEIVING RAIL HIGH 120 15%
AVERAGE OF 813 JOINTS 813 = 100%
JOINT
3"
2"
1"
½"
0
0
1/128
1/64
LEAVING RAIL
BOSTON & MAINE R.R.
RECEIVING RAIL

Chart 3

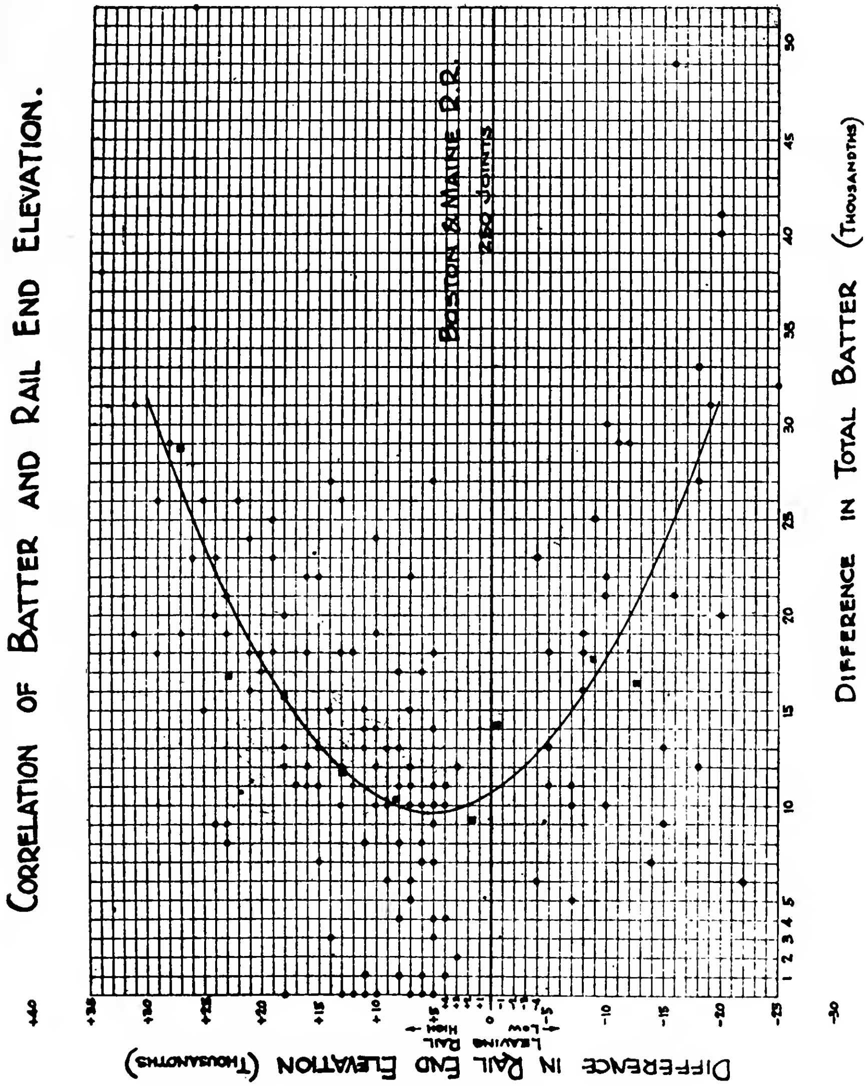

Correlation of Batter and Rail End Elevation.
Boston & Maine R.R.
250 Joints
Difference in Total Batter (Thousandths)
Difference in Rail End Elevation (Thousandths)
Leaving Rail
High
Low

Chart 4

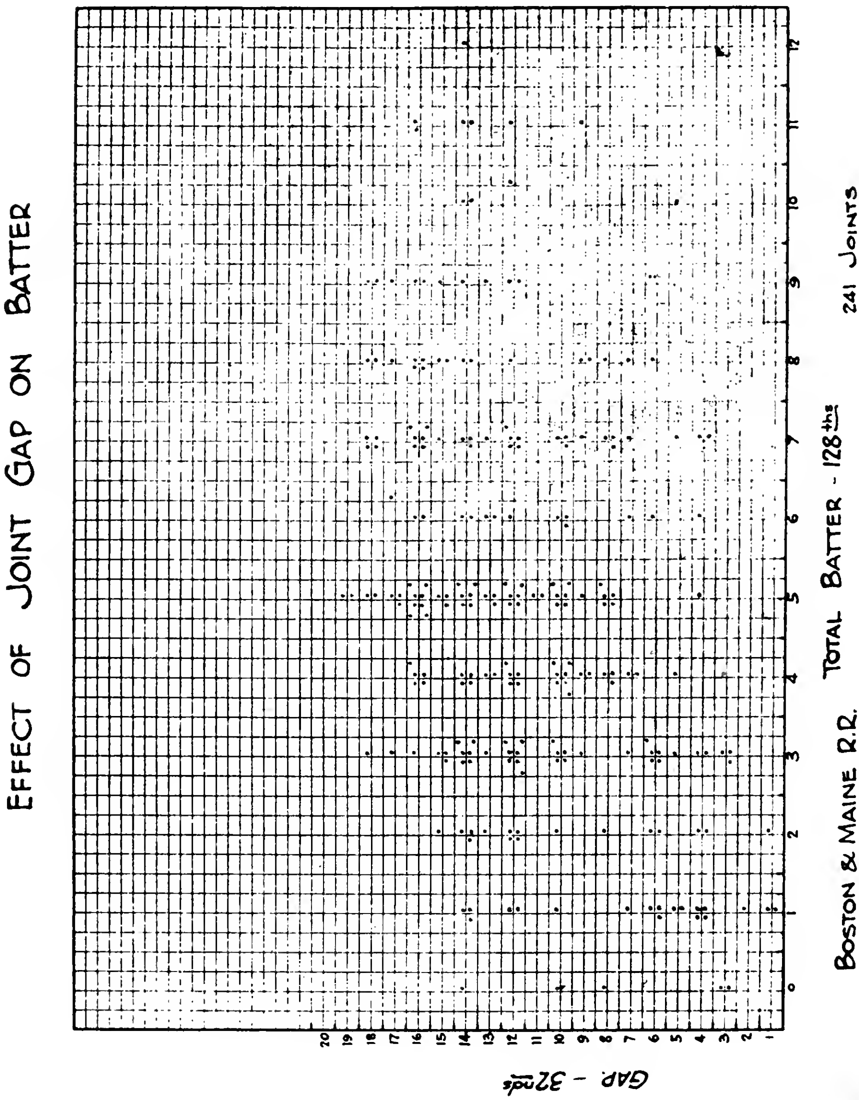

EFFECT OF JOINT GAP ON BATTER
BOSTON & MAINE R.R.
TOTAL BATTER - 128ths
241 JOINTS
GAP - 32nds
0 1 2 3 4 5 6 7 8 9 10 11 12
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Chart 5

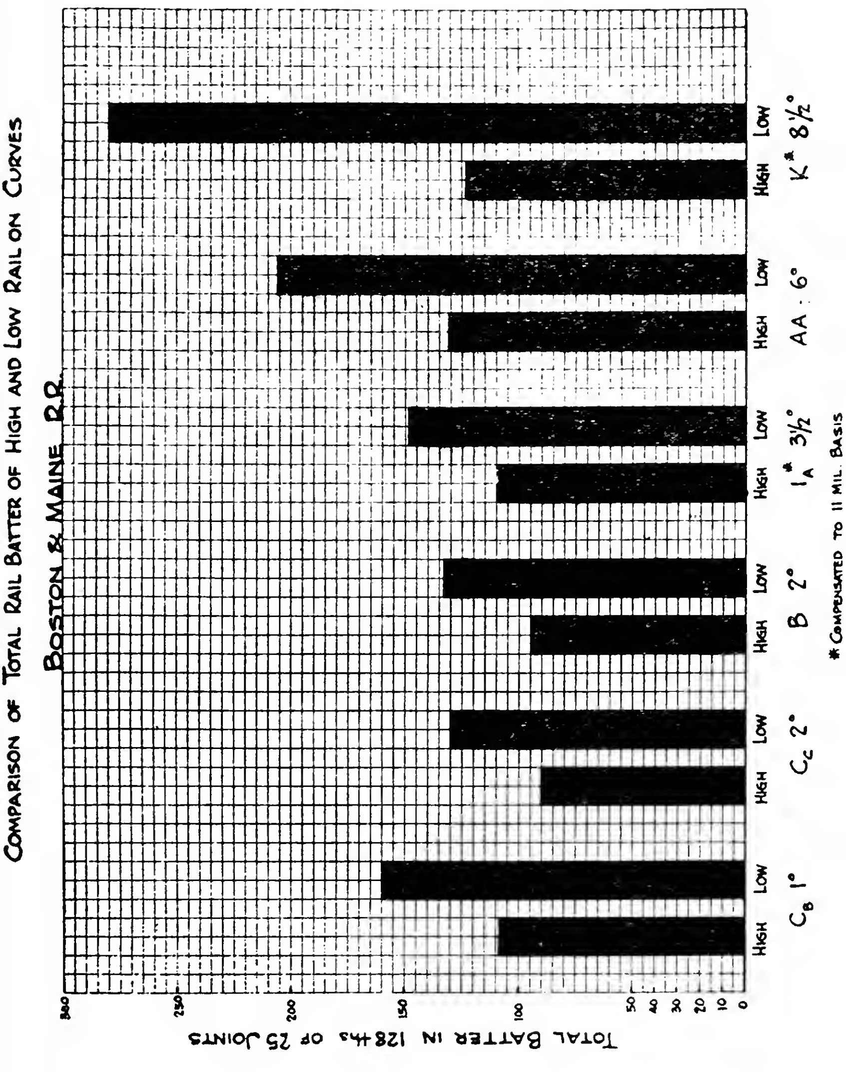

Comparison of Total Rail Batter of High and Low Rail on Curves
Boston & Maine R.R.
High
Low
C_B 1°
C_C 2°
B 2°
1_A* 3½°
AA 6°
K* 8½°
* Compensated to 11 Mil. Basis
Total Batter in 128ths of 25 Joints
300
250
200
150
100
50
40
30
20
10
0

Chart 6

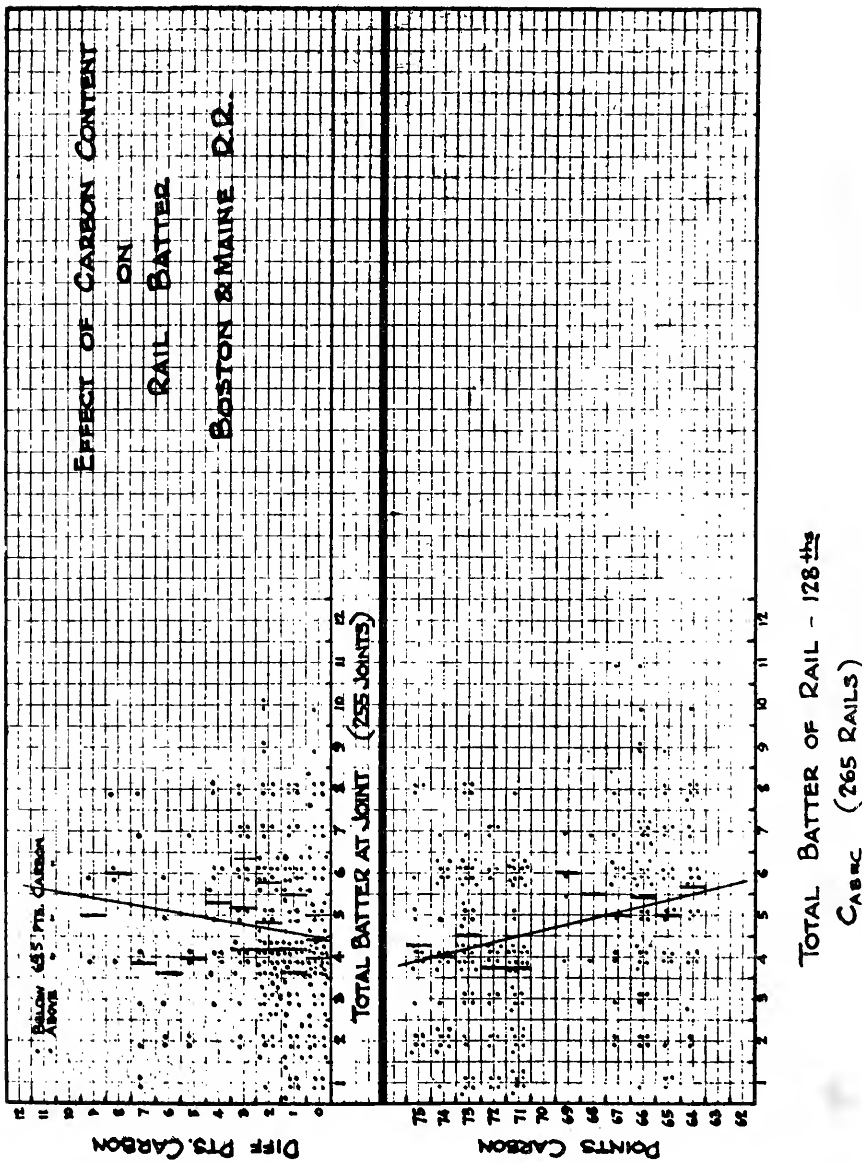

EFFECT OF CARBON CONTENT
ON
RAIL BATTER
BOSTON & MAINE R.R.
TOTAL BATTER AT JOINT (255 JOINTS)
DIFF PTS. CARBON
POINTS CARBON
TOTAL BATTER OF RAIL - 128ths
(265 RAILS)

Chart 7

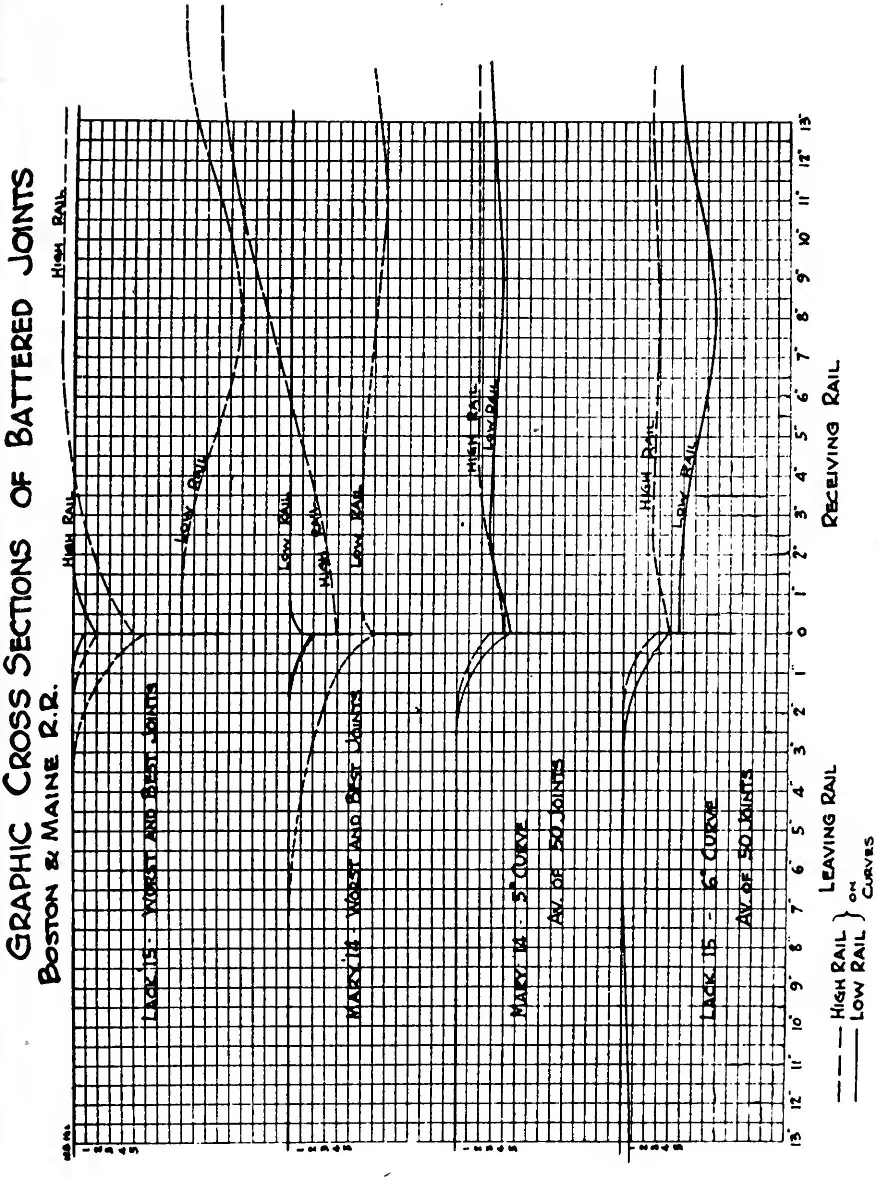

GRAPHIC CROSS SECTIONS OF BATTERED JOINTS
BOSTON & MAINE R.R.
LACK. 15 - WORST AND BEST JOINTS
MARY. 14 - WORST AND BEST JOINTS
MARY. 14 - 5° CURVE
AV. OF 50 JOINTS
LACK. 15 - 6° CURVE
AV. OF 50 JOINTS
HIGH RAIL
LOW RAIL
RECEIVING RAIL
LEAVING RAIL
HIGH RAIL
LOW RAIL
ON CURVES

Chart 8

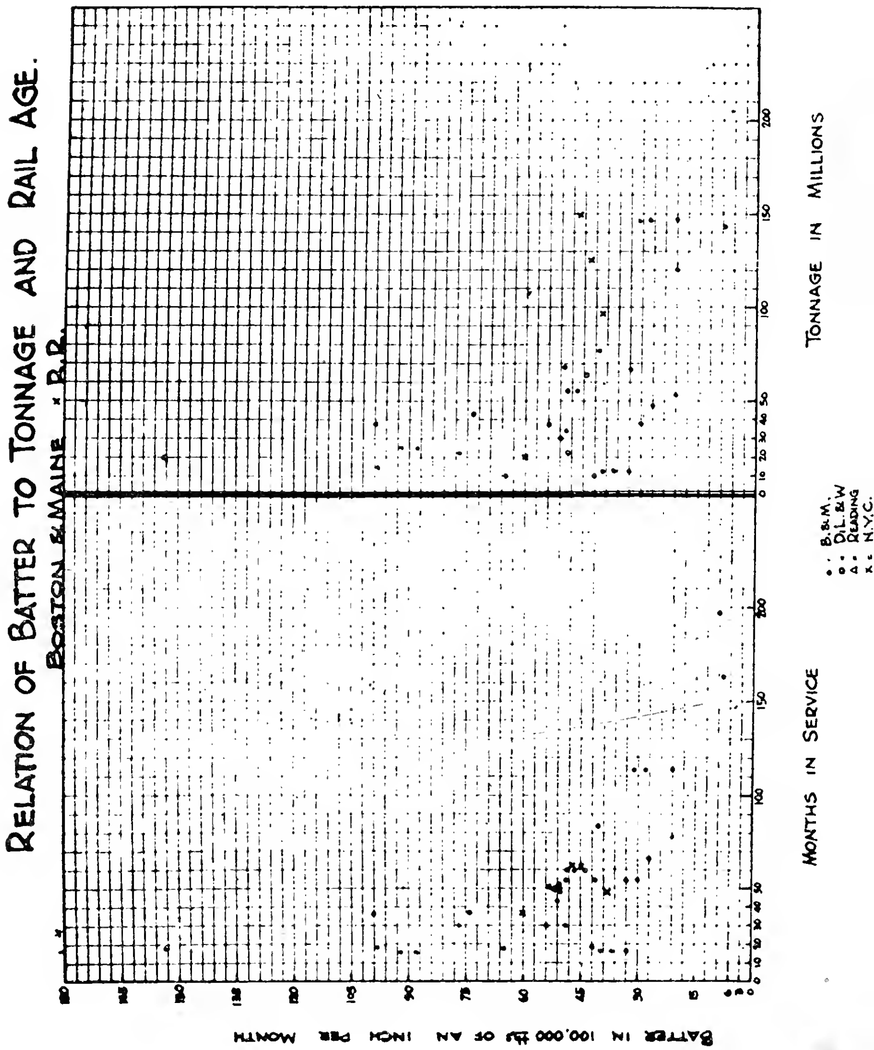

RELATION OF BATTER TO TONNAGE AND RAIL AGE.
BOSTON & MAINE R.R.
TONNAGE IN MILLIONS
MONTHS IN SERVICE
B.& M.
D.L.& W
READING
N.Y.C.
BATTER IN 100,000ths OF AN INCH PER MONTH

Chart A

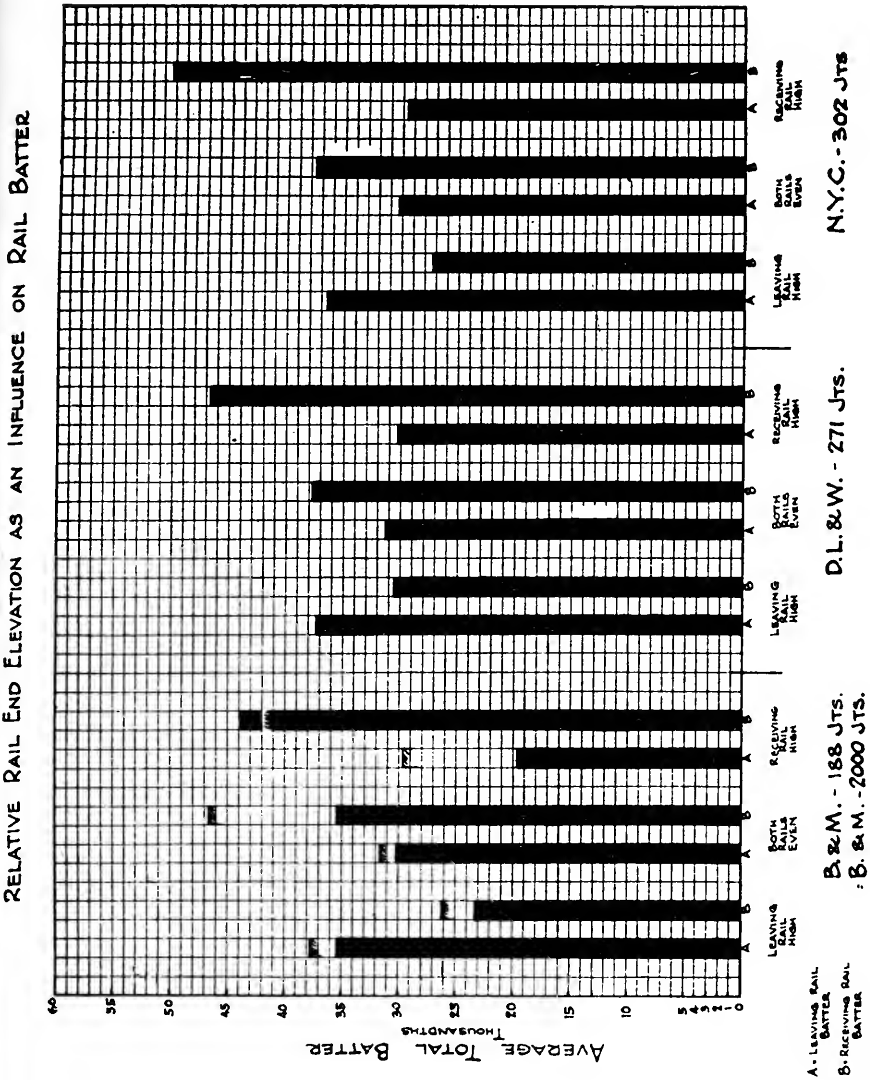
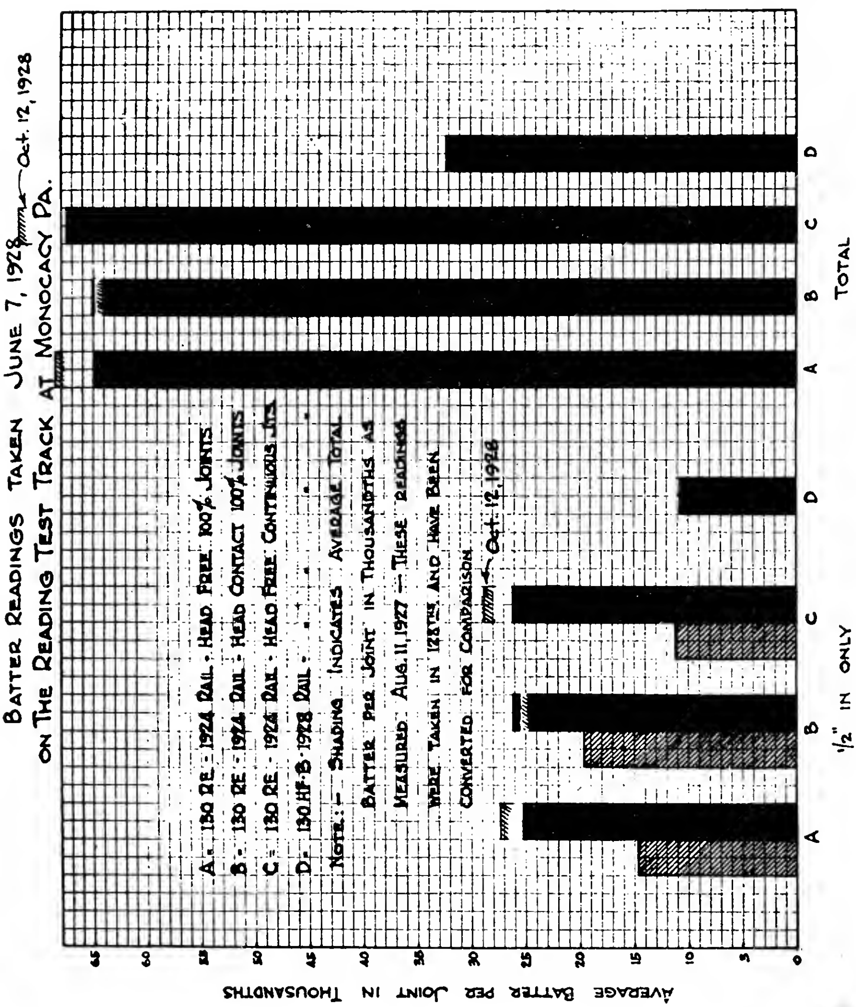

Relative Rail End Elevation as an Influence on Rail Batter
Average Total Batter
Thousandths
Leaving Rail High
Both Rails Even
Receiving Rail High
N.Y.C. - 302 Jts
D.L.&W. - 271 Jts.
B.&M. - 188 Jts.
B.&M. - 2000 Jts.
A - Leaving Rail Batter
B - Receiving Rail Batter

Chart B



Batter Readings Taken June 7, 1928
on The Reading Test Track at Monocacy Pa.
Oct. 12, 1928
A = 130 RE - 1924 Rail - Head Free 100% Joints
B = 130 RE - 1924 Rail - Head Contact 100% Joints
C = 130 RE - 1924 Rail - Head Free Continuous Jts
D = 130 HF-B - 1928 Rail - " " "
Note:- Shading Indicates Average Total Batter per Joint in Thousandths as Measured Aug. 11, 1927 — These readings were taken in 128ths and have been converted for comparison
Oct. 12, 1928
Average Batter per Joint in Thousandths
½" in only
Total
A
B
C
D
0
5
10
15
20
25
30
35
40
45
50
55
60
65

Appendix E

(5) STUDY OF ECONOMIC VALUE OF DIFFERENT SIZES OF RAIL

A. F. Blaess, Chairman, Sub-Committee; E. E. Adams, J. B. Baker, J. M. Farrin, C. R. Harding, C. W. Johns, H. C. Mann, A. W. Newton, G. J. Ray, W. P. Wiltsee, L. Yager, J. M. Young, W. C. Barnes.

Your Committe presents as information the following:

(1) A theoretical study showing stresses in the various rails caused by same loading and also how a change in size of rail affects pressure on subgrade, stress in rail, stiffness of track and how pressure on subgrade varies with stiffness of track.

(2) A practical study (which is incomplete) showing cost of owning and maintaining 85-lb. and 90-lb. rail for various traffic densities.

Theoretical Study

The theoretical study of the various rails is based on tests made and formulas developed by the A.R.E.A. Special Committee on Stresses in Railway Track as reported in Volume 19, page 875, of the Association's Proceedings from which on page 887 the following formulas are taken:

$$\text{Maximum bending moment in rail} = P\sqrt[4]{\frac{EI}{64U}}$$

$$\text{Maximum track depression} = \frac{P}{\sqrt[4]{64EIU^3}}$$

$$\text{Maximum intensity of upward pressure} = P\sqrt[4]{\frac{U}{64EI}}$$

and from page 804, Vol. 21, A.R.E.A. Proceedings:

$$\text{Maximum pressure on subgrade} = Pc = \frac{16.8Pa}{h^{2.15}}$$

In the above formulas:

P = equipment single wheel load that will produce same bending moment as set of wheels being considered.
E = modulus of elasticity of steel in rail.
I = moment of inertia of rail.
U = modulus of elasticity of rail support and is number of pounds per lineal inch of each rail necessary to depress track 1 inch.

The function of a rail is to transmit the wheel loads to the ties and in order to do this must possess a head of such shape and hardness as to stand the pound and wear of the wheels and also sufficient girder strength to distribute the wheel loads to the ties without undue stress. From this it is seen that the economy of a rail is dependent upon its head to resist wear and its general cross section to resist stress, the former being determined from experience gained by actual use in the track, while the latter is more subject to theoretical computations. In the theoretical study only stress in the base will be considered.

From the above it is apparent that the first thing to do in studying the economic value of the different rails is to compute their stresses for varying conditions of roadbed and in order that results throughout this discussion may be directly comparable all stresses will be computed for Illinois Central 2-10-2 type of engine running 50 miles per hour and having wheel loads and spacing as shown on Chart "A." This has been done and the results plotted on Chart "A" which show plainly how the different rails compare with each other under the same load and track conditions. Attention is called to the fact that the curves representing the different rails are practically parallel to each other and that stress in rail becomes less as *U*, the roadbed factor of stiffness increases. However, from the formula given above it is to be noted that the bending moment and consequently the stress varies as the fourth root of *U*, so that its effect is not very great.

By referring to page 184, Bulletin 291, Vol. 28, A.R.E.A., for November, 1926, a chart showing variation of values of *U* for different track make-ups will be seen from which it is to be noted that a fairly average track has a value of *U* equal to 1400. Now if we take this value of *U* and by means of Chart "A" determine stress in each of the different rails, the results can be plotted as shown in Chart "B," which indicates how stress varies with the weight of rail. It is interesting to note that slope of line from 70 lb. to 85 lb. (which were old A.S.C.E. sections) is greater than from 90 lb. to 136 lb., which represent the later sections showing that in the early days the principal idea in increasing weight of rail was to lessen stress, while the later sections evidently distributed the metal for wear and lateral stiffness as well as stress. Attention is directed to the practically straight line above 90 lb., indicating that for all practical purposes distribution of metal is constant. Chart "C" shows the moments of inertia of the same rails used in Chart "B" plotted against their stress, giving a curve similar to that of Chart "B" and indicating that as heavier rails are designed their moment of inertia increases in about the same ratio as their weight.

Changing weight of rail affects the stiffness of the entire track structure and by referring to Charts 7 and 8, pages 184 and 185, Bulletin 291, Vol. 28, A.R.E.A., for November, 1926, we can tabulate the stiffness of track factor *U* and the pressure in tons per square foot on subgrade for each weight of rail using 7 by 9 by 8 feet 6 inch tie as follows:

TABLE 1—DEPTH OF BALLAST

Wt.	6 Inches		9 Inches		12 Inches		15 Inches		18 Inches		21 Inches		24 Inches	
	U	Pressure	U	Pressure	U	Pressure	U	Pressure	U	Pressure	U	Pressure	U	Pressure
85 lb.	1125	4.35	1170	2.50	1230	1.68	1280	1.30	1320	0.90	1390	0.71	1440	0.58
90 lb.	1180	3.90	1225	2.25	1290	1.50	1350	1.25	1400	0.84	1450	0.66	1510	0.52
100 lb.	1230	3.80	1290	2.15	1340	1.43	1410	1.21	1460	0.76	1525	0.61	1580	0.49
110 lb.	1300	3.35	1375	1.92	1430	1.30	1500	1.00	1550	0.68	1600	0.55	1650	0.45
127 lb.	1440	2.95	1500	1.68	1550	1.13	1600	0.79	1650	0.60	1700	0.48	1750	0.39
136 lb.	1550	2.70	1600	1.48	1640	0.98	1700	0.71	1740	0.55	1800	0.45	1850	0.36

The effect of weight of rail on U can be shown graphically by taking values from Table 1 and plotting them as is done in Chart D, which shows that U increases uniformly on a straight line as weight of rail increases and that this rate of increase is the same for all depth of ballast, being 8 for each pound increase in weight of rail.

Likewise Chart E was constructed from values of pressure on subgrade given in Table 1 and it is interesting to note as indicated by slope of curves that as ballast is increased in depth the size of rail has a lessening effect on the pressure.

Also by means of Table 1 Chart F was constructed, showing how value of U varies with different pressure values and different depths of ballast for the various sizes of rails, this chart being useful in arriving at approximate relation between U and pressure on subgrade.

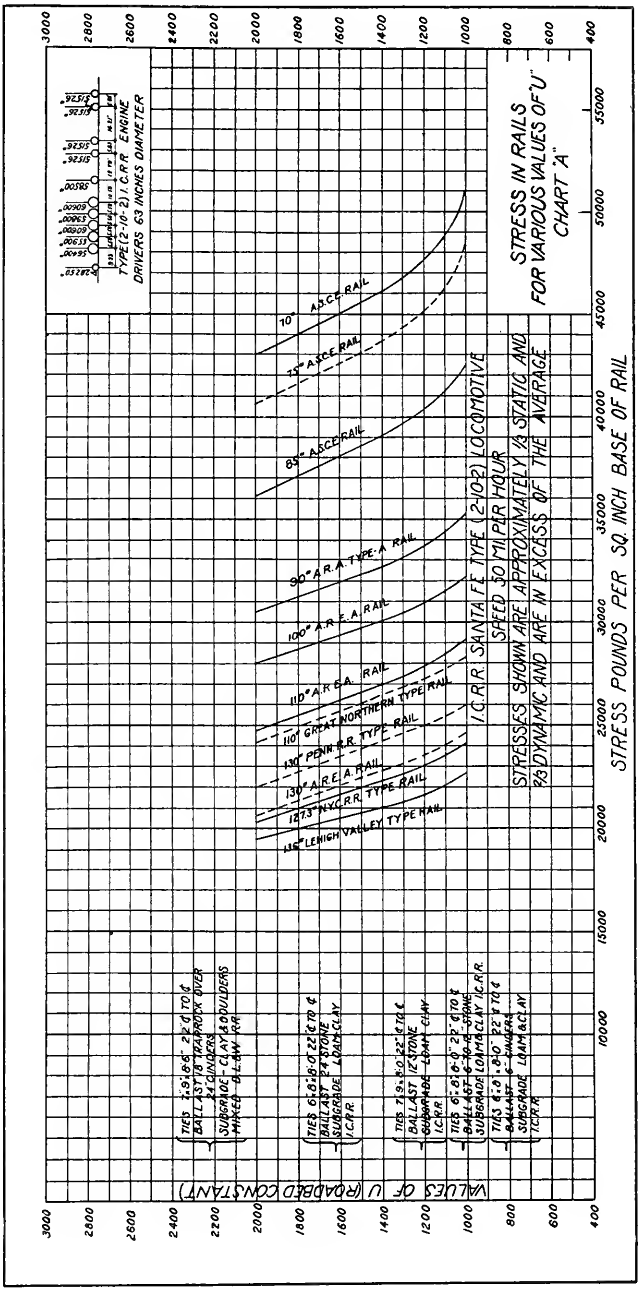
In the above discussion we have seen how the different sizes of rail affect the stiffness of track U, pressure on subgrade and stress in rail under same conditions of loading, but what is wanted is information on how much better is a track with a certain size rail than one of some other size. A very good idea of this can be obtained by assuming say a track with 7 by 9 by 8 foot 6 inch ties on 15-inch ballast and tabulate values from Table 1 as follows:

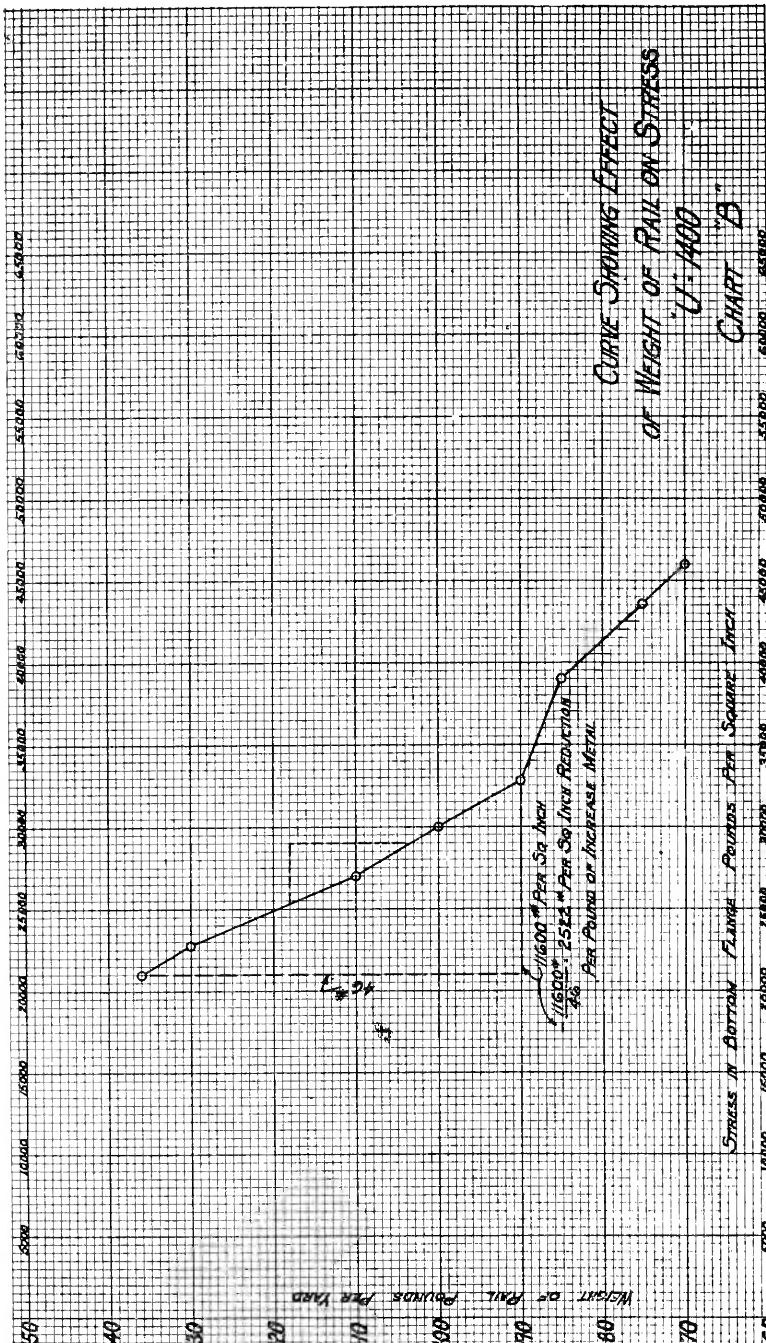
Weight of Rail	*U*	*Pressure Tons per Sq. Ft. on Subgrade*	*Stress in Bottom Flange from Chart A Pounds*
70-lb. A.S.C.E.	1145	1.85	48200
75-lb. A.S.C.E.	1190	1.60	45200
85-lb. A.S.C.E.	1270	1.30	39800
90-lb. A.R.A.—A.	1310	1.15	33000
100-lb.	1395	1.05	30200
110-lb. A.R.E.A.	1480	0.90	26600
127-lb. N.Y.C.	1620	0.80	21500
136-lb. Lehigh	1690	0.70	20300

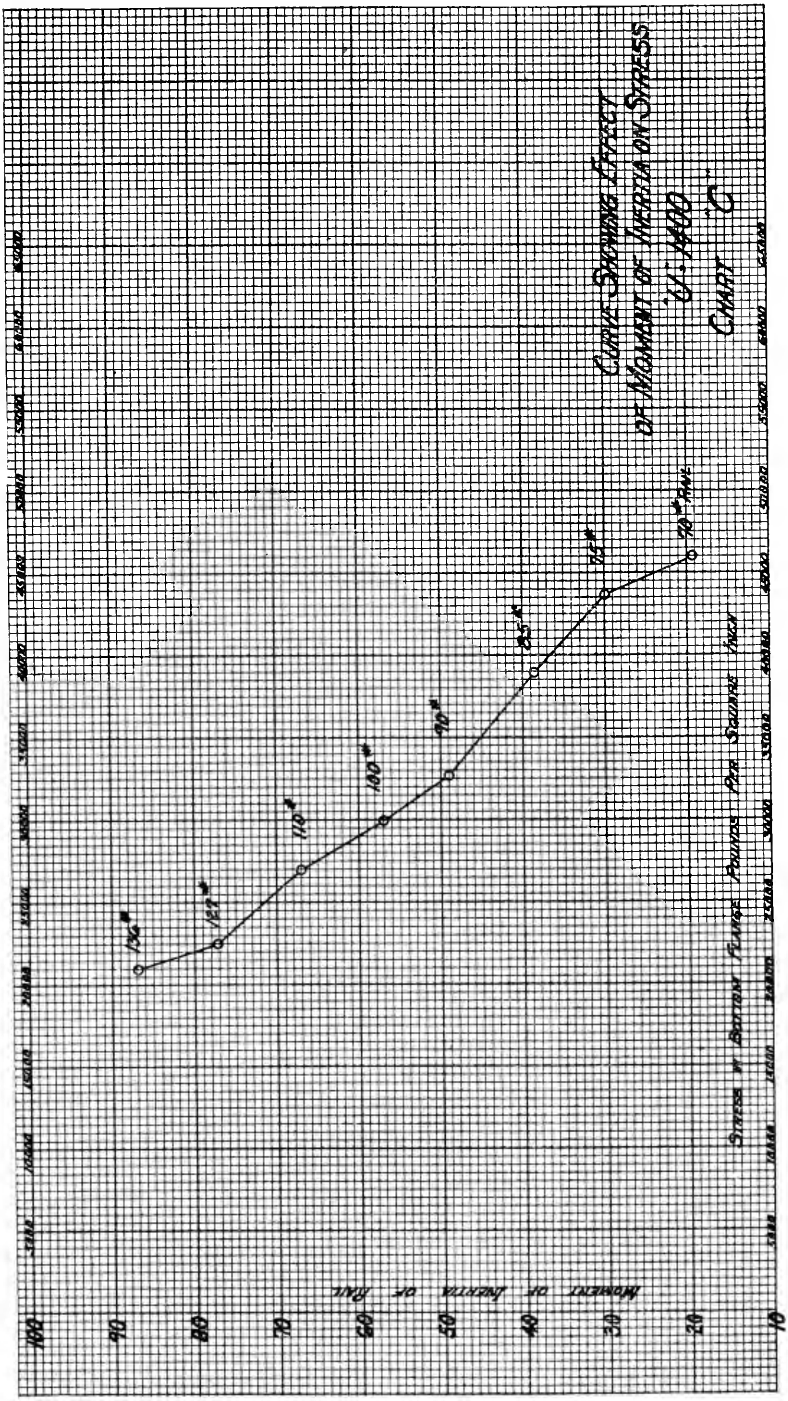
If now we take the values of 70-lb. rail as unity and figure per cent increase for each of the other size rails, Chart G can be constructed showing per cent increase in values of U, stress in rail and pressure on subgrade as rail is increased in weight. An inspection of these curves shows that U can be increased 47½ per cent, stress in rail decreased 58 per cent and pressure on subgrade decreased 62 per cent. Just exactly how these three component qualities affect the entire track structure from a practical standpoint is not known, but the probability is that it is in the neighborhood of 50 per cent, that is, that the track as a whole can be bettered 50 per cent by changing from 70-lb. to 136-lb. rail, everything else remaining the same.

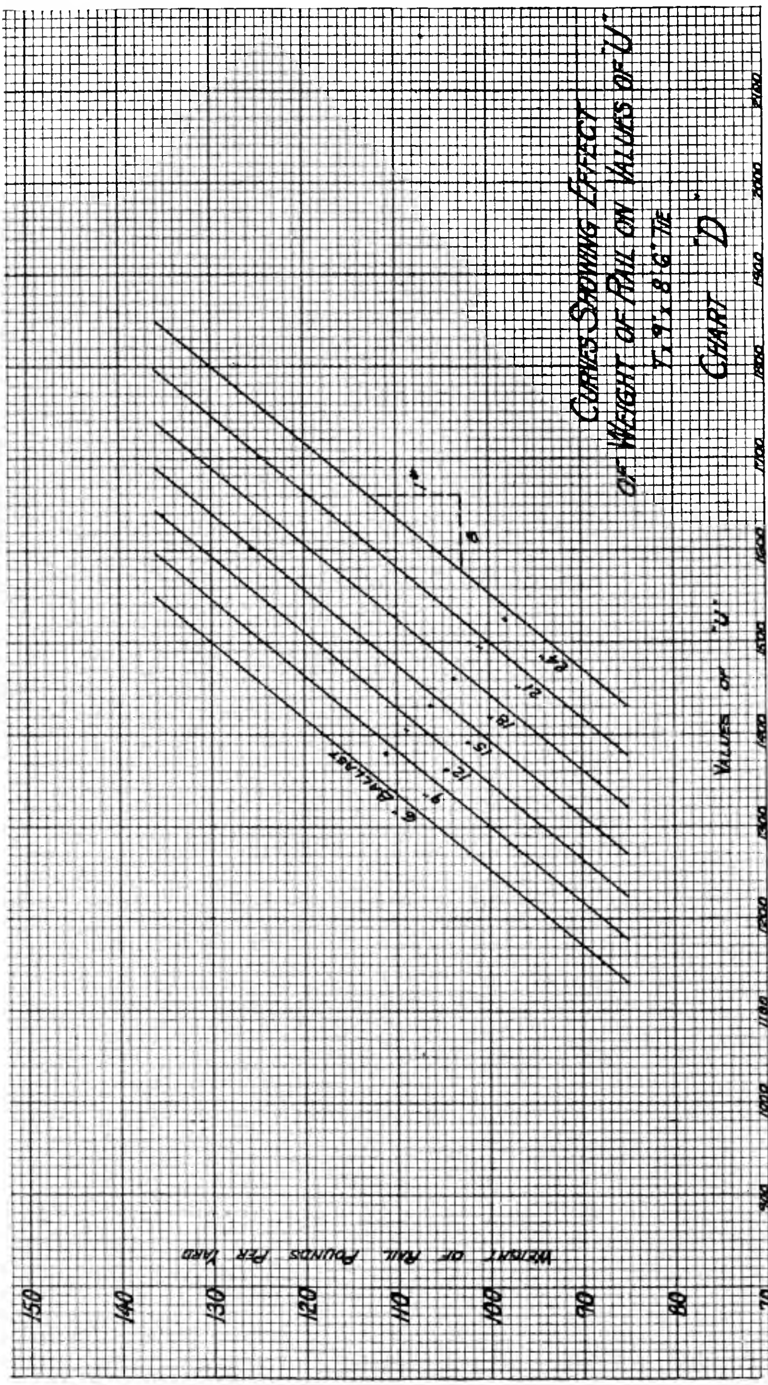
Practical Study

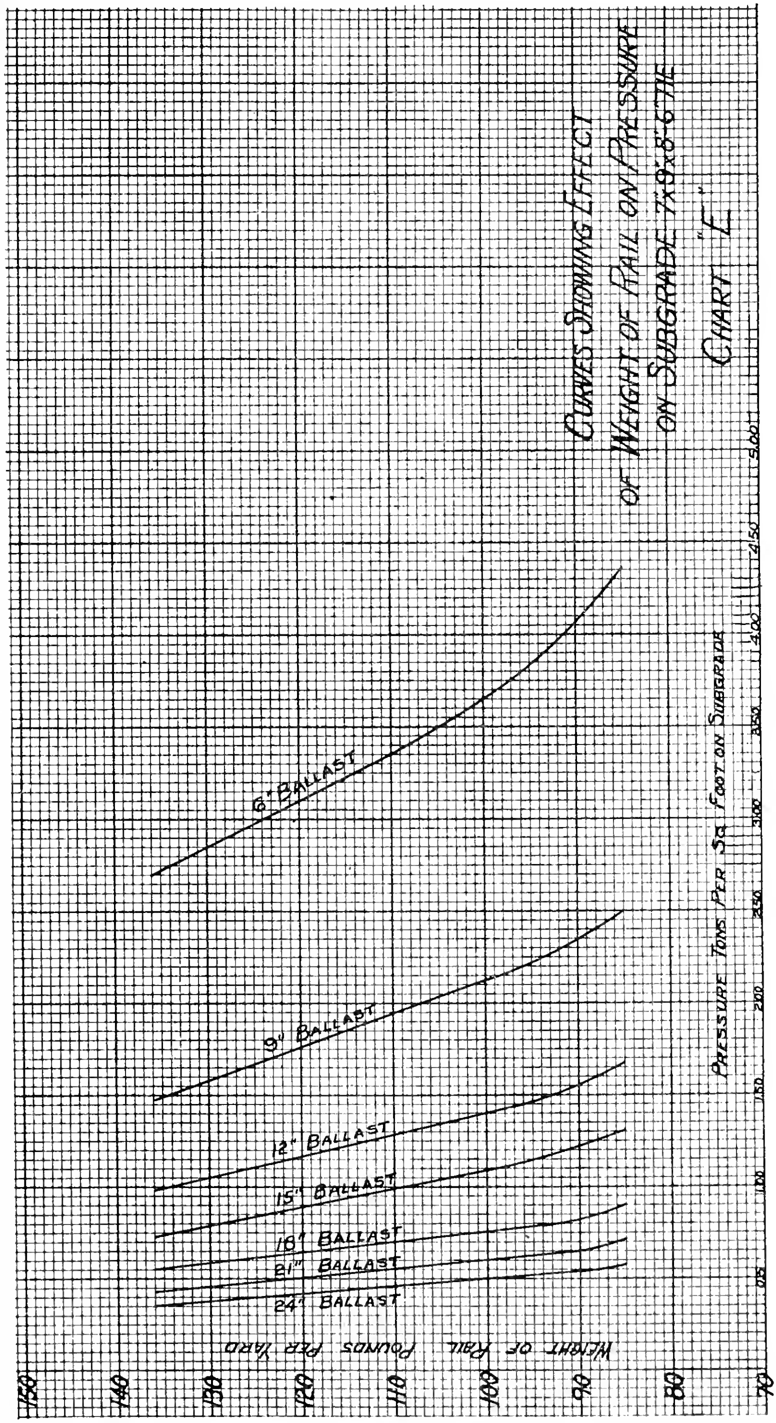
An investigation made over a 100-mile stretch of double track railway through Illinois on the Illinois Central Railroad was made for a 26-year period 1901 to 1926, inclusive, and amount of section labor per year for each mile of each track determined together with rail renewals and traffic carried. This track in 1901 was 85-lb., being gradually replaced with 90-lb. in the later years. The information obtained was plotted on Chart H, showing costs in cents per million gross ton miles for varying traffic densities. On this same chart the results obtained by J. B. Baker, Engineer of Maintenance, Pennsylvania Railroad, and presented by him in a paper read before the Roadmasters' and Maintenance of Way Association at their 1920 convention, were also plotted by converting cars per day into gross ton miles per year by multiplying number of cars by 48.4, which was average loading per car on Pennsylvania for 1921. It is to be noted that a discrepancy exists between the Illinois Central results and the Pennsylvania results, the Illinois Central costs being somewhat higher. Not sufficient data is at hand at the present time to determine the correctness of any of these curves, but they are given to show progress and how the problem is being attacked. It is hoped that with additional data for all weights of rail sufficient information can be obtained that curves for each weight can be plotted so that their intersections will give the economical traffic density to change rails.

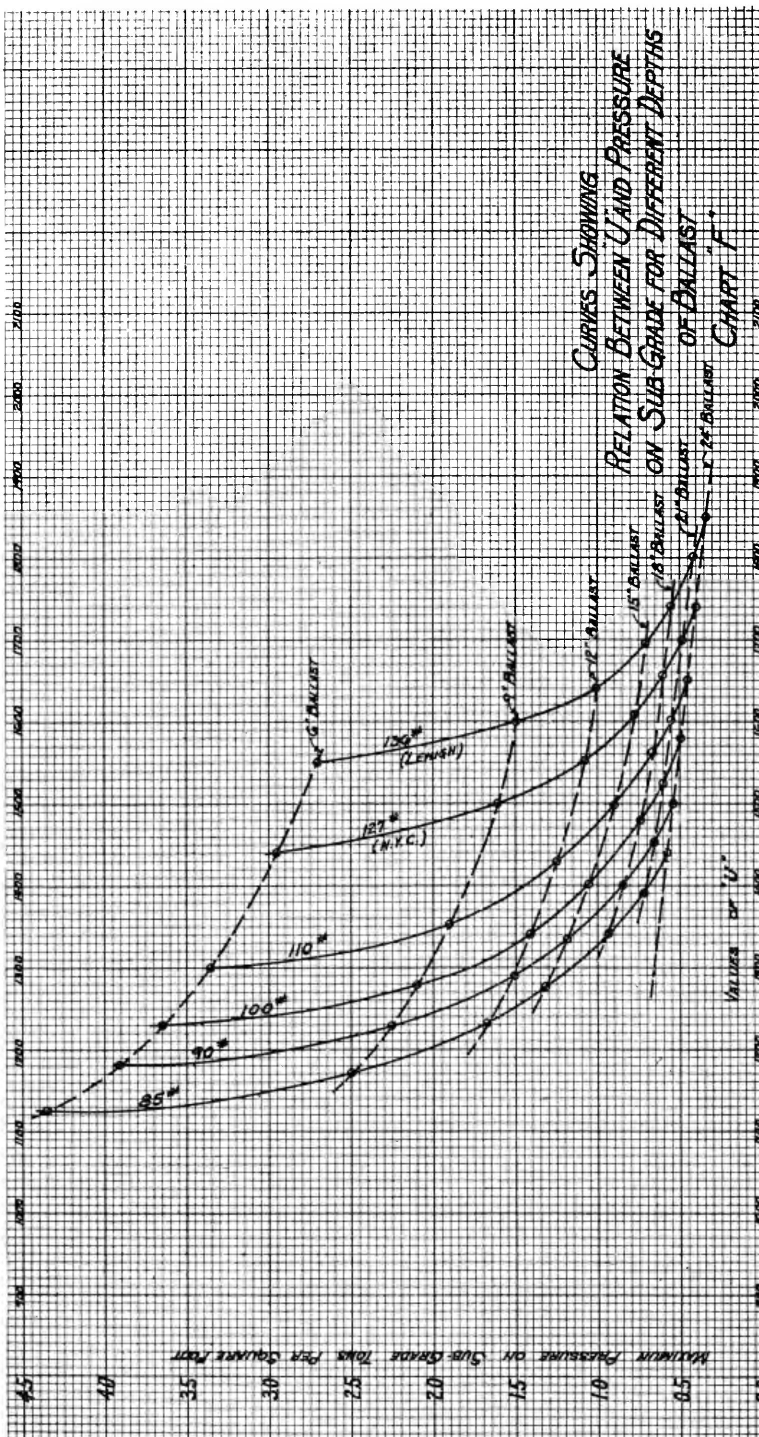

STRESS IN RAILS
FOR VARIOUS VALUES OF "U"
CHART "A"
TYPE (2-10-2) I.C.R.R. ENGINE
DRIVERS 63 INCHES DIAMETER
70" A.S.C.E. RAIL
75" A.S.C.E. RAIL
85" A.S.C.E. RAIL
90" A.R.A. TYPE-A RAIL
100" A.R.E.A. RAIL
110" A.R.E.A. RAIL
110" GREAT NORTHERN TYPE RAIL
130" PENN. R.R. TYPE RAIL
130" A.R.E.A. RAIL
127.3" N.Y.C.R.R. TYPE RAIL
135" LEHIGH VALLEY TYPE RAIL
I.C.R.R. SANTA FE TYPE (2-10-2) LOCOMOTIVE
SPEED 50 MI. PER HOUR
STRESSES SHOWN ARE APPROXIMATELY 1/3 STATIC AND
2/3 DYNAMIC AND ARE IN EXCESS OF THE AVERAGE
STRESS POUNDS PER SQ. INCH BASE OF RAIL
VALUES OF U (ROADBED CONSTANT)

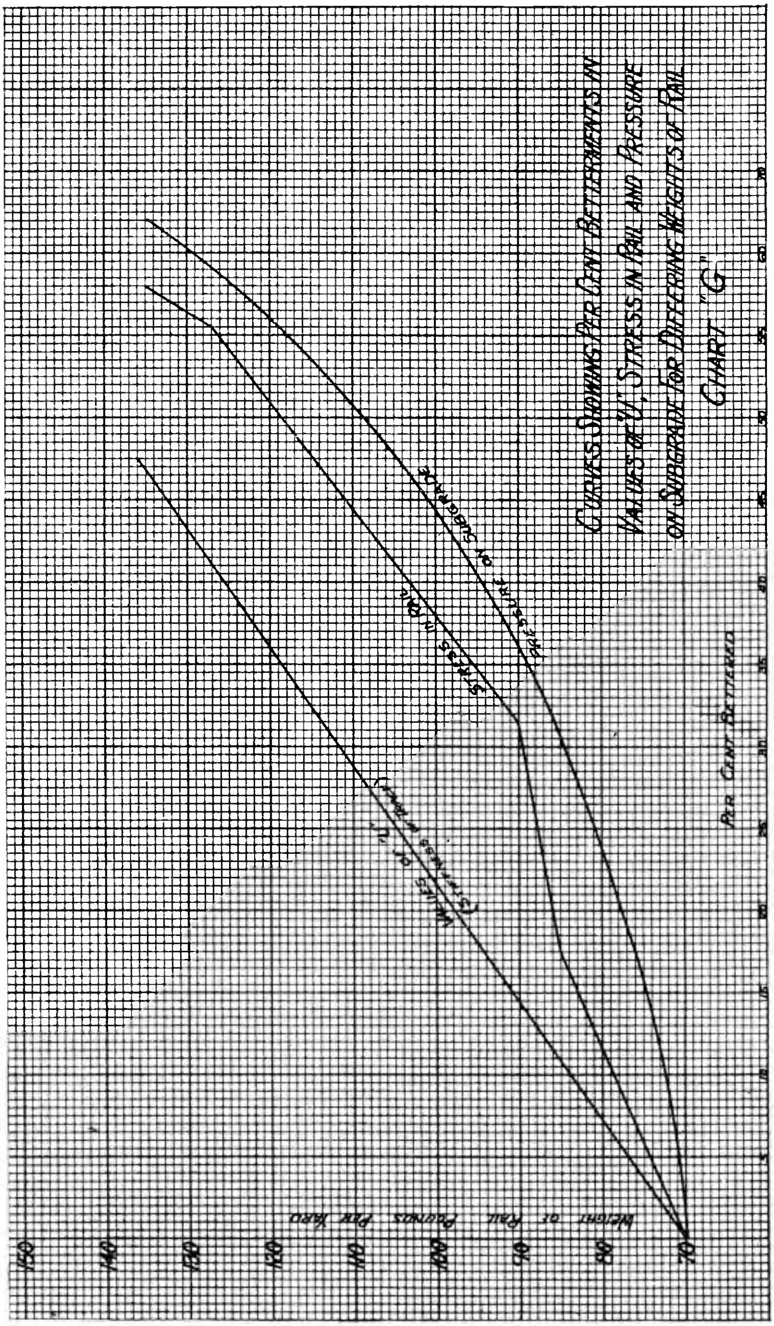

Curve Showing Effect
of Weight of Rail on Stress
"U" 1400
Chart "B"
Stress in Bottom Flange Pounds Per Square Inch
Weight of Rail Pounds Per Yard
11600# Per Sq Inch
11600#/46 = 252# Per Sq Inch Reduction
Per Pound of Increase Metal
46#
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
55000
60000
65000
60
70
80
90
100
110
120
130
140
150

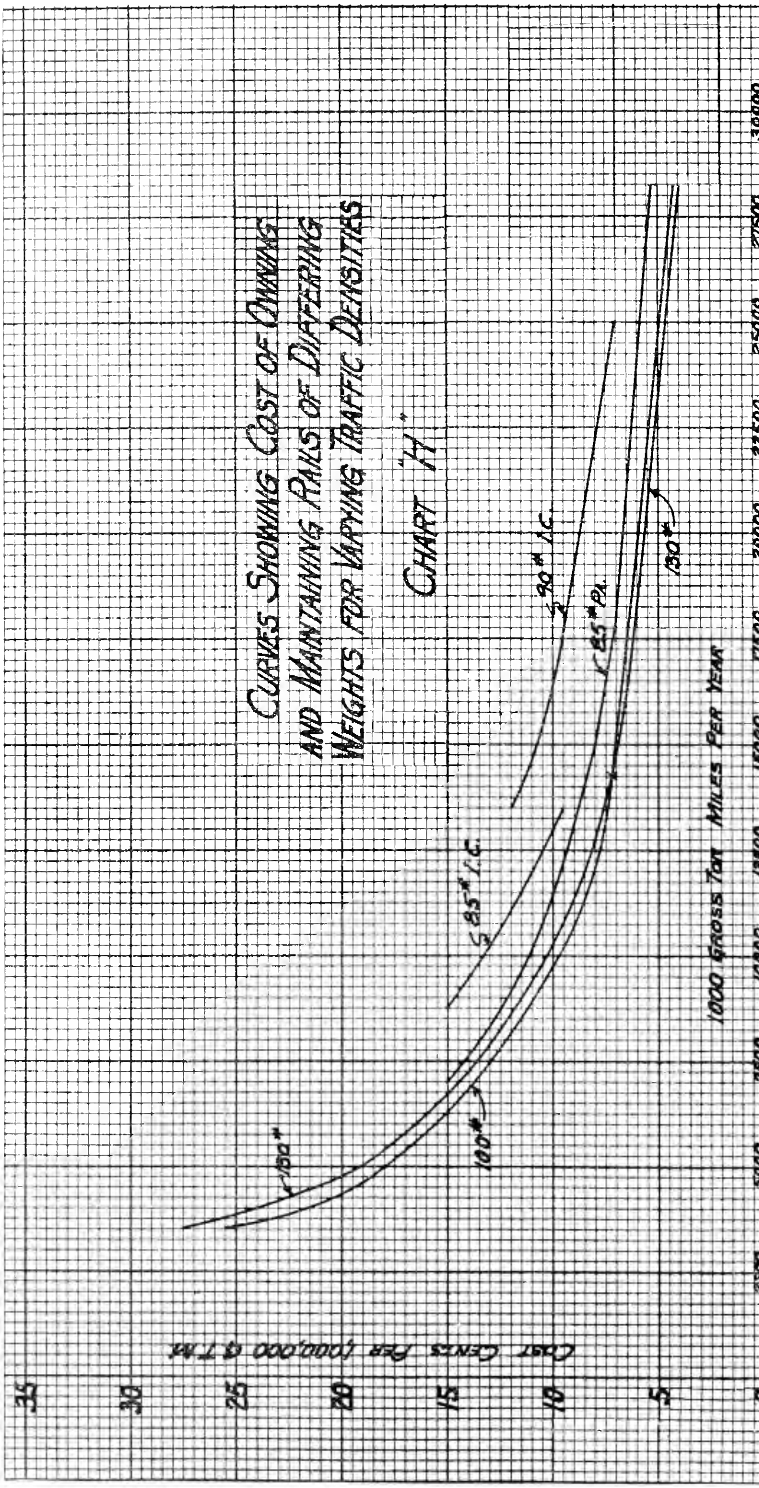

Curve Showing Effect
of Moment of Inertia on Stress
"U" 1400
Chart "C"
Stress in Bottom Flange Pounds Per Square Inch
Moment of Inertia of Rail
136#
127#
110#
100#
90#
85#
75#
70# Rail


Curves Showing Effect of Weight of Rail on Values of "U"
Chart "D"
Values of "U"
Weight of Rail Pounds Per Yard
6" Ballast
9"
12"
15"
18"
21"
24"
150
140
130
120
110
100
90
80
70


CURVES SHOWING EFFECT
OF WEIGHT OF RAIL ON PRESSURE
ON SUBGRADE 7"x9"x8'-6" TIE
CHART "E"
PRESSURE TONS PER SQ FOOT ON SUBGRADE
WEIGHT OF RAIL POUNDS PER YARD
6" BALLAST
9" BALLAST
12" BALLAST
15" BALLAST
18" BALLAST
21" BALLAST
24" BALLAST
150
140
130
120
110
100
90
80
70


Curves Showing
Relation Between "U" and Pressure
on Sub-Grade for Different Depths
of Ballast
Chart "F"
Maximum Pressure on Sub-Grade Tons Per Square Foot
Values of "U"
85#
90#
100#
110#
127# (N.Y.C.)
130# (Lehigh)
6" Ballast
9" Ballast
12" Ballast
15" Ballast
18" Ballast
21" Ballast
24" Ballast
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0


Curves Showing Per Cent Betterments in
Values of "U", Stress in Rail and Pressure
on Subgrade for Differing Weights of Rail
Chart "G"
Per Cent Bettered
Weight of Rail Pounds Per Yard
Values of "U" (Stiffness of Track)
Stress in Rail
Pressure on Subgrade
70
80
90
100
110
120
130
140
150
5
10
15
20
25
30
35
40
45
50
55
60
70



Curves Showing Cost of Owning
and Maintaining Rails of Differing
Weights for Varying Traffic Densities
Chart "H"
90# I.C.
85# Pl.
130#
85# I.C.
130#
100#
1000 Gross Ton Miles Per Year
Cost Cents Per 1000,000 G.T.M.
0
5
10
15
20
25
30
35
2500
5000
7500
10000
12500
15000
17500
20000
22500
25000
27500
30000

Appendix F

(6) CONTINUE THE STUDY OF THE RECONDITIONING OF BATTERED OR WORN RAIL ENDS BY THE ELECTRIC AND OXY-ACETYLENE WELDING PROCESSES, WITH ESPECIAL REFERENCE TO THE EFFECT UPON RAIL

E. E. Adams, Chairman, Sub-Committee; Lem Adams, J. E. Armstrong, A. F. Blaess, C. B. Bronson, E. A. Hadley, C. R. Harding, Hunter McDonald, W. H. Penfield, F. M. Waring, J. B. Young, W. C. Barnes.

For the past two years your Committee has been studying this subject and has made numerous laboratory tests and field observations with reference to this matter.

For the oxy-acetylene process, the laboratory tests consisted of detailed examination of nine typical battered rail ends that were built up by an ordinary welder. After welding, the rail welds were polished and tested for hardness with a field type of Brinell machine, and it was found that the average hardness on the top of the rail was slightly greater than that of the original rail metal, while the hardness on the side of the head was slightly less, probably due to heating affects. A section cut through at approximately one-half inch from the end indicated that the oxy-acetelene process resulted in a tendency to very slightly soften the base metal. From four typical samples examined, the average hardness of metal at the center of the weld is eight points above that of the original metal, but at the junction of the weld and base metal it is five points below.

Specimens Nos. 4 and 8 in statement of oxy-acetylene welded rail ends (Exhibit A) were treated with an excess of acetylene flame, which shows that, if desired, a high range of hardness may be secured with the acetylene flame. All of the other specimens represent typical practice of performance in the field.

For electric welded rails, your Committee secured samples of welded rail ends from a representative electric rail welding company and selected four samples from those furnished, all of which were 90-lb. A.R.A. rail. The hardness of the metal on top of the rail is slightly less than that of the base metal, while the hardness on the side of the head is approximately the same as that of the base metal, which indicates that there is no appreciable affect on the base metal from heating when the electric process is used (Exhibit B).

The object of the laboratory tests for hardness was to determine whether or not the heat applied in connection with either of these processes would be detrimental to the base metal in the rail, and it is our opinion that the heat from either process is in no way harmful. We also wished to determine whether or not the metal applied was of sufficient hardness to withstand the action of wheel loads, and we find that the welded material, when properly applied, is in every respect equal to the normal rail metal.

We have made many observations of rail built up by both methods of welding referred to, and find that welded rail ends will stand up at least as long as the original rail ends did, without becoming battered. We also find that, where the life of the rail will warrant, the rail may be built up a second and even a third time, providing that the welds should fail due to service or other cause.

Since battered rail ends are so detrimental to track, we consider that the cost of building up battered rail is many times repaid in lessened track maintenance.

Photographs showing rail built up by each process, accompany this report. The metal that has been welded on is very clearly indicated in the photographs.

The practice of reconditioning rail ends by the welding process is now so generally used by the railroads in America that the Committee has not thought necessary to mention details of practice, as acetylene welding has been in general use for more than five years and electric welding has been considerably used since assignment of this subject, and the railroads are familiar with the method.

Your Committee therefore recommends that the following conclusion be approved for printing in the Manual:

"The reconditioning of rail ends by either electric or oxy-acetylene welding has not been found detrimental to the rail. Either method gives an adequate wearing surface to the rail ends when the metal is properly applied. It provides an economical means for restoring battered rail ends to their true surface, and is recommended as good practice."

Exhibit A

Hardness Test on Oxy-Acetylene Welded Rail Ends
Laboratory Tests for A.R.E.A.

Specimen No.	*Rail Section*	*Hardness in Top of Head*								*Hardness on Side of Head*				
		½"	*1"*	*2"*	*3"*	*4"*	*5"*	*6"*	*7"*	*½"*	*1"*	*2"*	*3"*	*4"*
1	90-lb. A.R.A.	279	...	250	...	292	...	...	295	243	250	...	...	243
2	90-lb. A.R.A.	232	250	250	263	...	...	276	...	243	256	219	...	...
3	90-lb. C.S.	250	226	244	238	278	290	...	...	224	225	219	225	263
4	90-lb. C.S.	270	273	277	256	237	263	...	250	244	257	250	257	216
5	100-lb. R.E.	264	257	280	264	...	250	...	...	250	274	272	250	264
6	90-lb. A.R.A.	265	250	250	243	236	...	257	...	221	...	228	250	257
7	100-lb. R.E.	256	256	262	250	277	276	...	...	250	...	244	...	250
8	100-lb. R.E.	263	263	269	262	250	...	...	...	271	270	250	...	255
9	90-lb. A.R.A.	250	250	250	250	238	250	...	267	224	230	250	250	...
Average........		259	253	259	253	244	266	266	271	241	252	242	246	249

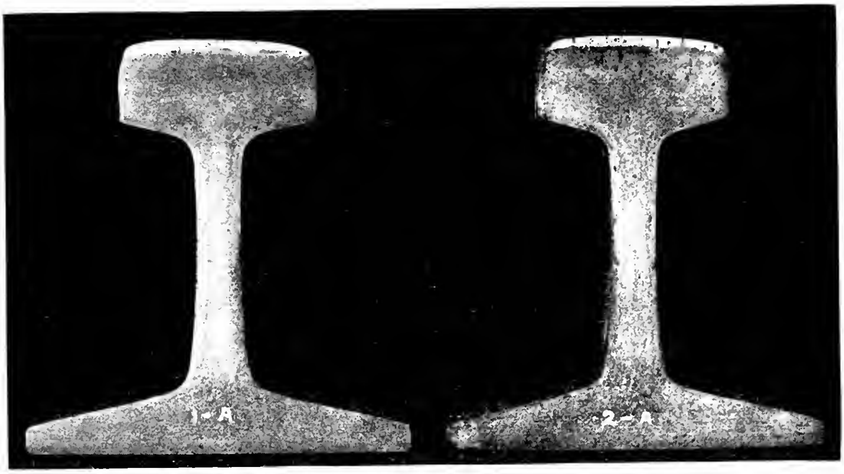
Note—The inches shown in statement represent the distance of readings from end of rail.

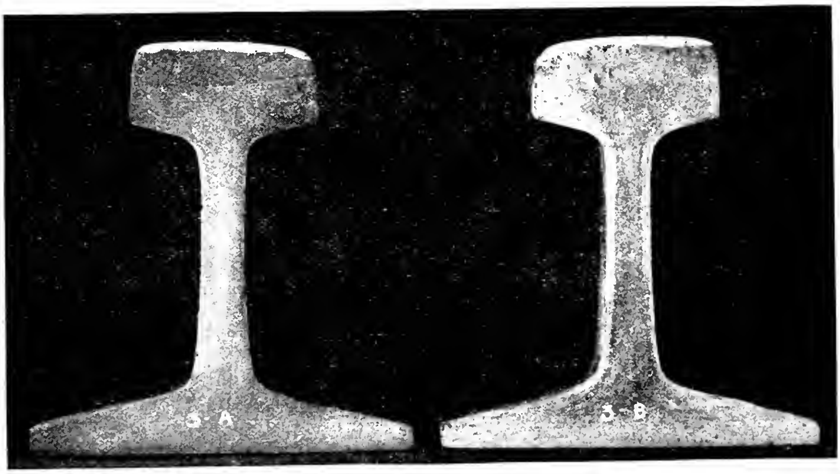
Exhibit B

Hardness Test on Electric Welded Rail Ends
Laroratory Tests for A.R.E.A.

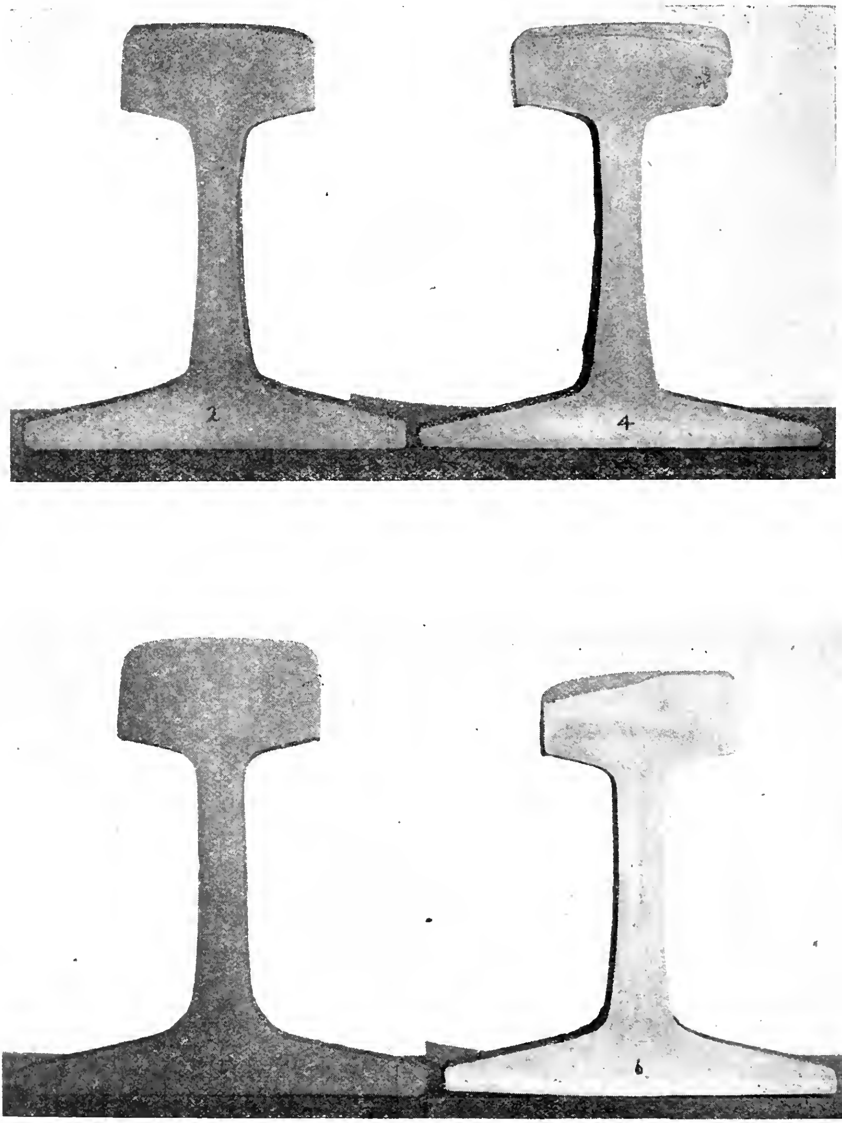
Specimen No.	*Rail Section*	*Hardness in Top of Head*								*Hardness on Side of Head*				
		½"	*1"*	*2"*	*3"*	*4"*	*5"*	*6"*	*7"*	*½"*	*1"*	*2"*	*3"*	*4"*
1-A	90-lb. A.R.A.	217	230	238	238	246	232	...	...	253	262	...	...	...
2-A	" "	235	244	236	236	236	244	...	252	237	230	...	...	...
3-A	" "	232	248	237	244	254	262	262	...	...	262	243	262	262
3-B	" "	230	217	236	246	231	234	...	262	243	244	244	245	...
Average........		229	235	237	241	242	243	262	257	244	250	243	253	262

Note—The inches shown in statement represent the distance of readings from end of rail.





Rails Built Up by Welding Process



Rails Built Up by Oxy-Acetylene Welding Process

Rails Built Up by Oxy-Acetylene Welding Process

Appendix G

(9) COMPILE INFORMATION OF TESTS OF ALLOY STEEL RAILS, ADDRESSING THE VARIOUS RAILROADS FOR RECORDS OF SUCH TESTS AS THEY MAY HAVE MADE

R. T. Scholes, Chairman, Sub-Committee; J. E. Armstrong, C. B. Bronson, E. E. Chapman, C. R. Harding, C. P. Van Gundy, G. J. Ray, J. B. Young, F. M. Waring, W. C. Barnes.

Owing to the widespread interest in intermediate manganese rail the Committee decided, in undertaking this assignment, to confine its efforts for the present to securing as complete data as possible with respect to this class of rail. With this end in view questionnaire (Exhibit A) was addressed to railroads that have purchased intermediate manganese rail and the data submitted herewith has been secured from the replies.

Returns to the questionnaire indicate that from 1924 to 1928, inclusive, somewhat over 225,000 gross tons of intermediate manganese rail have been rolled and placed in service in the United States. The returns also indicate that the tonnage purchased is rapidly increasing.

The Committee desires to point out that on the whole the replies are favorable to intermediate manganese steel, particularly the Burlington, Lackawanna and New York Central Lines who purchased 213,112 tons out of the 229,059 tons of intermediate manganese rails reported, as will be noted from their replies to the questionnaire. The Santa Fe report on 13,000 tons is favorable except as to the percentge of X-Rayls which is excessive, due in a large measure to the special treatment given the ingots.

The Pennsylvania and the Reading Railroads, with tonnages of 942 and 300 tons respectively, report unfavorable results, but it should be pointed out that these small tonnages were of an experimental nature with excessive variations in the percentages of carbon and manganese. The Pennsylvania rejected two heats due to drop test failures out of the 16 heats reported. Both heats were high in manganese and carbon. Five other heats were over the specified limits in chemistry but were accepted for experimental purposes and study. Their unsatisfactory results were apparently due to these unusual variations. The Reading in their 300 tons had four heats shipped, three of the heats being 0.45 carbon or less, which together with the comparatively low manganese content made them quite soft, and produced unsatisfactory service results. The fourth heat with 0.72 carbon and 1.30 manganese is still in track and giving satisfactory service.

Exhibit B shows the following tabulated information:

1. Tonnage purchased by mills, years, sections and weight per yard.
2. Carbon limits specified.
3. Manganese limits specified.
4. Other special requirements.

In addition to the foregoing the following information with regard to inspection tests, results in service and general conclusions is abstracted from the replies received to the questionnaire:

Atchison, Topeka & Santa Fe Railway Company (13,000 tons)

5. (a) Drop Tests:

	Plain Carbon		*Intermediate Manganese*	
Weight	90-lb.	110-lb.	90-lb.	110-lb.
Number of test pieces	..	126	22	222
Broke on first blow, per cent	..	0.00	0.00	0.00
Height of drop, ft.	18	20	18	20
Supports C to C, ft.	3	4	3	4
(b) Exhausted Ductility:				
Average number blows required to break	..	4.2*	3.5†	4.4‡
(c) Deflection on first blow, in.	..	0.89	1.21	1.01

(d) Segregation Tests:

Plain carbon, 42 heats average 6.4 per cent positive segregation, Middle over Outside position.

Intermediate manganese 244 heats average 2.5 per cent positive segregation,

Middle over Outside position.

	Plain Carbon	*Intermediate Manganese*
(e) Ball Indentation Tests:		
Number tests	27	244
Depth of indentations, ¾ in. ball, 100,000-lb. load, in.	0.106	0.102
(f) Percentage X-Rayls to all rails accepted:		
90-lb.	...	10.45
110-lb	0.62	17.2
(g) Percentage of piped rails to all rails accepted:		
90-lb.	...	10.45
110-lb.	0.62	17.2
(h) Percentage of second quality rails to first quality rails accepted:		
90-lb.	...	2.46
110-lb.	5.8	4.10
(i) Fatigue Tests: None, Izod Impact Test:		
Average of 15 breaks, ft.-lb.	2.19	...
Average of 114 breaks, ft.-lb.	...	4.32
(j) Tensile Tests: No information		

6. No transverse fissures have been reported on Intermediate Manganese rail to date.
7. No head failures have been reported on Intermediate Manganese rail to date; one failure through web on a No. 2 X-Rayl which had a seam in web.
8. Present specifications satisfactory, but aim to keep both carbon and manganese well below the maximum.
9. No information.

*Average of plain carbon, 126 heats.

†Average of 22 heats, two samples were nicked and broken for intermediate manganese 90-lb. rail.

‡Average of 222 heats, 191 samples were nicked and broken.

Chicago, Burlington & Quincy Railroad Company (58,700 tons)

5. (a) Drop Tests:

	Ordinary O.H.			Intermediate Mang.		
Weight	90-lb.	100-lb.	110-lb.	90-lb.	100-lb.	110-lb.
No. Test Pieces	1376	1109	...	689	842	651
Per cent broke on 1st blow	1.74%	.54%	...	2.61%	1.42%	1.22%
Ht. of drop	18′	19′	20′	18′	19′	20′
Supports C to C	3′	3′	4′	3′	3′	4′

(b) Exhusted Ductility:

	Ordinary O.H.			Intermediate Mang.		
Average number blows required to break	90-lb.	100-lb.	110-lb.	90-lb.	100-lb.	110-lb.
	3.8	4.6	3.5	4.5	5.1	5.0

(c) Deflection on 1st Blow:

Ordinary O.H.			Intermediate Mang.		
90-lb.	100-lb.	110-lb.	90-lb.	100-lb.	110-lb.
1.32″	1.09″	.97″	1.20″	1.05″	.89″

(d) Segregation Tests:
Ordinary O.H..... 79 heats Av. 9.8% plus Seg. M over O position
Intermediate Mang. 54 heats Av. 4.3% plus Seg. M over O position

(e) Ball Indentation Tests:

	Ordinary O.H.	Intermediate Mang.
Number of tests	814	801
Depth of indentation 19 MM ball. 100,000-lb.	0.110″	0.103″

(f) Percentage of X-Rails to All Rails Accepted:
Ordinary O.H. .... .703%
Intermediate Mang. 1.510%

(g) Percentage of Piped Rails to All Rails Accepted:
Ordinary O.H. .... .703%
Intermediate Mang. 1.510%

(h) Percentage of Second Quality Rails to First Quality Rails Accepted:
Ordinary O.H. .... 5.44 %
Intermediate Mang. .... 4.73 %

(i) Fatigue Tests:
No information.

(j) Tensile Tests:
No information.

Note to Question 5.

(a) Drop Tests. The higher percentage of failures on the 1st blow in IM rail probably due to fact that a particular effort was made to keep the carbon content high in this class of steel.

(b) The Ball Indentation Tests. They are not considered entirely satisfactory or reliable. It is hoped to get more reliable data in future by means of improved gages.

6. No transverse fissures have been reported in Intermediate Manganese rail to date.
7. Head failures in Intermediate Manganese rail.
No data.
8. We have no changes in specifications for Intermediate Manganese rail under consideration.
9. We have no specific data on comparative service obtained from Intermediate Manganese rail and Ordinary O.H. rail. In general our maintenance engineers are very favorably impressed with performance of Intermediate Manganese rail during the limited time it has been in service.
10. Have no further information to present.

Delaware, Lackawanna & Western Railroad Company (71,162 tons)

5. (a) Drop Test:

Rail Section	*Weight of Tup*	*Fall of Tup*	*Distance Between Supports*	*Blows Required*
105	2000-lb.	19′	3′	2
118	2000-lb.	19′	3′	2
130	2000-lb.	19′	4′	2

Specification requires three test pieces from each heat to stand two blows each without fracture. All test pieces that will stand them are given two additional blows for information only. The test is discontinued after four blows on account of distortion.

	130-lb. Med. Mng.	*118-lb. Med. Mng.*	*118-lb. Plain O.H.*	*105-lb. Med. Mng.*	*105-lb. Plain O.H.*
5. (b) Ductility after 2nd blow avg.	.25 See Note A	.33	.32	.39	.52
(c) Deflection after 1st blow avg.	.71 See Note A	.89	.91	1.06	1.14
(d) Carbon segregation avg.	7% See Note A	8.5%	10%	8%	6%
(f) Percentage of X-Rayls......	0.5% See Note A	No Data	No Data	No Data	No Data
(g) Percentage of piped heats at drop test	4.3% See Notes A and B	17%	32%	8%	8%
(h) Percentage of 2nd quality rails	3.16% See Note A	3%	3.5%	2.5%	9%

Note A—130-lb. Rail Med. Mn. average taken from 210 heats (16,200 tons) rolled in 1928, carbon 0.57 to 0.70 and manganese 1.20 to 1.50. 118-lb. Rail Med. Mn. average taken from 40 heats (2,913 tons) rolled in 1924, carbon 0.54 to 0.67 and manganese 1.20 to 1.50. 118-lb. Rail Plain Open Hearth average taken from 40 heats (3,004 tons) rolled in 1924, carbon 0.67 to 0.80 and manganese 0.60 to 0.90. 105-lb. Rail Med. Mn. average taken from 49 heats (3,664 tons) rolled in 1928, carbon 0.54 to 0.67 and manganese 1.20 to 1.50. 105-lb. Rail Plain Open Hearth average taken from 49 heats (3,450 tons) rolled in 1924, carbon 0.64 to 0.77 and manganese 0.60 to 0.90.

Note B—Percentage of pipe shown represents heats which showed pipe at the drop test. No special record is kept of piped rails found on inspection bed. Such rails are classed as rejected rails.

(e) Specifications do not require Brinell test.
(i) Specifications do not require fatigue tests.
(j) Specifications do not require tensile tests.

6. No transverse fissures have developed to date in medium manganese rail.
7. Head failures developed:

	Types of Head Failures	
	Split Head	*Crushed Head*
105-lb. rail rolled 1926........................	None	None
105-lb. rail rolled 1927........................	None	None
105-lb. rail rolled 1928........................	None	None
118-lb. rail rolled 1925........................	None	None
130-lb. rail rolled 1925........................	3	2
130-lb. rail rolled 1926........................	12	None
130-lb. rail rolled 1927........................	8	None
130-lb. rail rolled 1928........................	2	None

8. Have about reached the conclusion that carbon should be kept between 0.54 and 0.67 and the manganese between 1.35 and 1.60.
9. (a) Wear on Curves:
   See Exhibit "C."
   (b) Rail End Batter and Chipping:
   No data available.
   (c) Rate of Failures:
   Fifty-eight failures have developed to date in 8,870 tons of plain open hearth 118-lb. rolled in Nov., 1924, or 6.54 failures per 1,000 tons.
   In the 2,625 tons of medium manganese rolled in Jan., 1925, no failures have developed to date.

New York Central Railroad Company (83,250 tons)

5. (a) Drop Tests:
   Height of drop—20 feet for 105, 115 and 127-lb. sections.
   Supports, C. to C.—105-lb., 3 feet; 115 and 127-lb., 4 feet.
   Results at Mill A:
   20,000 tons medium manganese, 105 and 127-lb.—No rejections.
   40,000 tons standard open hearth, 105 and 127-lb.—No rejections.
   Results at Mill B:
   12,000 tons medium manganese, 127-lb.—21 heats rejected.
   12,000 tons standard open hearth, 127-lb.—15 heats rejected.
   10,000 tons medium manganese, 105-lb.—1 heat rejected.
   25,000 tons standard open hearth, 105-lb.—10 heats rejected.
   Rejections were made either for breakage on first blow or insufficient ductility.
   Results at Mill C:
   1,000 tons medium manganese, 105-lb.—No rejections.
   14,000 tons standard open hearth, 105-lb.—1 heat rejected.
   Results at Mill D:
   2,840 rails rolled, medium manganese, 115-lb.—27 rails rejected.
   3,982 rails rolled, standard open hearth, 115-lb.—No rails rejected.
   (b) Total elongation in base of rail in 6 inches after three blows:

Plant	*127 O.H.*	*127 I.M.*	*105 O.H.*	*105 I.M.*
A	0.30 to 0.45	0.35 to 0.50	0.50 to 0.70	0.50 to 0.70
B	0.30 to 0.50	0.30 to 0.45	0.45 to 0.70	0.50 to 0.75

   (c) Deflection on first blow:

Plant	*127 O.H.*	*127 I.M.*	*105 O.H.*	*105 I.M.*
A	0.75 to 0.90	0.75 to 0.90	1.05 to 1.20	1.00 to 1.20
B	1.00 to 1.10	0.90 to 1.10	1.00 to 1.30	0.90 to 1.20

   (d) We have made several experiments, taking sections from the top end of the A rail from every ingot of heats of both standard open hearth and medium manganese from four different rail mills. There was a striking difference in the appearance of sulphur prints, as the medium manganese rail sections were decidedly cleaner and freer from segregation than the corresponding standard open hearth sections.
   (e) Do not require Brinell ball indentation test.
   (f) We have never followed the practice of X-rail classification. The general nick and break test practice has never been incorporated in our specifications.

(g) and (h) Per cent piped rails and per cent second quality:

Mill	*Section*	*Steel*	*Per Cent Piped*	*Per Cent Seconds*
A	127	O.H.	1.2	8.2
A	127	M.M.	0.8	4.4
A	105	O.H.	1.1	10.4
A	105	M.M.	1.5	6.8
B	127	O.H.	2.0	27.2
B	127	M.M.	3.6	19.6
B	105	O.H.	1.6	18.5
B	105	M.M.	2.2	8.0
C	115	O.H.	(*)	7.6
C	115	M.M.	(*)	7.2

*Included in scrap.

(i) Only a few fatigue tests made, with the following results:
Endurance limit, I.M. steel—40,000 to 55,000 lb.
Endurance limit, O.H. steel—40,000 to 45,000 lb.

(j) Average tensile properties:

	I.M.	*O.H.*
Elastic limit	68,000 to 87,000	55,000 to 66,000
Tensile strength	122,000 to 138,000	111,000 to 128,000
Elongation	10 to 15%	10 to 12%
Reduction of area........	17 to 32%	12 to 20%

6. Five interior transverse fissures in medium manganese rails have developed on the New York Central East. No fissures in this type of steel on any other road in the New York Central Lines. Details are as follows:

Date Failed	*Section*	*Mill*	*Rolled*	*Heat*	*Rail*	*Failed Near*	*Type of Fissure*
12- 4-27	105	Bethlehem	12- 5-26	27,555	B	Milepost 58	Transverse
1-13-28	127	Bethlehem	5- 6-26	24,209	B	Milepost 50	Compound
1-16-28	105	Bethlehem	3-25-25	84,130	H	Milepost 44	Transverse
2- 6-28	105	Bethlehem	12-29-25	28,572	D	Milepost 300	Transverse
3- 7-28	105	Bethlehem	12-28-25	22,927	B	Milepost 299	Transverse

7. Head failures in medium manganese rails:
   N. Y. C.-East—127-lb. rail, 12 split heads, 7 crushed heads; 105-lb. rail, 4 split heads, 19 crushed heads.
   N. Y. C.-West—127-lb. rail, none; 105-lb. rail, 5 split heads.
   Big Four—105-lb. rail, 18 horizontal crushed heads, of which 14 were in one heat.
   P. & L. E.—115-lb. rail, 1 split head.
   B. & A.—105-lb. rail, 1 split head.

   We have investigated several of the horizontal crushed heads and in every case have found the steel sound and homogeneous with the exception of shatter cracks. Evidently failure originated in these shattered areas.
8. No changes contemplated. Our present working basis and specification is entirely satisfactory.
9. (a) Incomplete data, but contours of rail heads in curves 4½ to 6 degrees indicate a reduction of approximately 10 per cent for rails on high side of curves.
   (b) Noticeable difference in both end and crosswise flow on rail head. Also less evidence of tendency to chip. This is one important feature of medium manganese steel.

(c) For some mills rate of failure for medium manganese is decidedly lower. For one mill rate of failure just about equal for medium manganese and standard open hearth.

No tonnage data available.

10. Our experience in the inspection of 83,000 tons medium manganese rails has shown from results of physical tests that the prescribed chemical limits are the desirable ranges. Furthermore, our experience indicates that the lowest and highest acceptable limits should be as follows in any case:

Carbon	0.50 minimum	0. 70 maximum
Manganese	1.20 minimum	1.70 maximum

As a general rule we have found low carbon and manganese associated together, and conversely high carbon and high manganese, so that heats outside of our specified ranges either tend to be soft or hard. Below 0.50 carbon and 1.20 managanese we consider the rails too soft and over 0.70 carbon and 1.70 manganese there is a noticeable tendency towards brittleness.

Summing up, the advantages of medium manganese steel are as follows:

(a) Cleaner steel with decidedly less segregation.
(b) Quieter setting steel.
(c) Much lower percentage of seconds and general freedom from flaws.
(d) Steel flows better in rolling.
(e) Much finer grain structure.
(f) Slightly lower deflection on first blow of drop and in general more blows to fracture with higher total ductility.
(g) Higher elastic limit and tensile strength.
(h) Lower rate of wear indicated on curves.
(i) Less tendency to batter and chip at rail ends.
(j) In general a lower rate of failure, including interior transverse fissures.

Disadvantages:

(a) Steel pipes more.
(b) Higher cost compared to standard open hearth.

Northern Pacific Railway Company (1,705 tons)

5. (a) Height of drop—100-lb. R. E., 19 feet; 130-lb. R.E., 22 feet. Supports, C. to C.—100-lb. R.E., 3 feet; 130-lb. R. E., 4 feet.

(b) Exhausted ductility:

100-lb. R.E.—Int. Mn., 9.0% to 14.3%, average 11.6%
100-lb. R.E.—Plain 6.9% to 13.5%, average 10.6%
130-lb. R.E.—Int. Mn., 7.9% to 11.7%, average 9.8%
130-lb. R.E.—Plain 4.1% to 12.3%, average 8.1%

(c) Permanent set, in inches:

100-lb. R.E.—Int. Mn., 0.95 to 1.30, average 1.11
100-lb. R.E.—Plain 1.10 to 1.35, average 1.20
130-lb. R.E.—Int. Mn., 0.75 to 1.05, average 0.85
130-lb. R.E.—Plain 0.75 to 1.05, average 0.78

(d) Segregation:

No tests made.

(e) Ball Indentation Tests. Diameter of indentation, 19 mm. ball, 100,000-lb. load.

100-lb. R.E.—Int. Mn., 12.0 to 13.5, average 13.1
100-lb. R.E.—Plain 14.0 to 13.0, average 13.5
130-lb. R.E.—Int. Mn., 13.0
130-lb. R.E.—Plain 13.0

(f) Percentage of X-Rayls to all rails accepted:

100-lb. R.E.—Int. Mn., 15.2%
100-lb. R.E.—Plain 2.5%
130-lb. R.E.—Int. Mn., 11.6%
130-lb. R.E.—Plain 1.1%

(g) Percentage of piped rails to all rails accepted: (Includes piped rails rejected and accepted.)

100-lb. R.E.—Int. Mn., 15.2%
100-lb. R.E.—Plain 2.5%
130-lb. R.E.—Int. Mn., 11.6%
130-lb. R.E.—Plain 1.1%

(h) Percentage of second quality rails to all rails accepted:

100-lb. R.E.—Int. Mn., 4.5%
100-lb. R.E.—Plain 8.1%
130-lb. R.E.—Int. Mn., 4.0%
130-lb. R.E.—Plain 9.2%

(i) No fatigue tests.

(j) Tensile Tests:

100-lb. R.E.	*Int. Mn.*	*Plain*
Elastic limit "O"	80,000 to 92,000	63,000 to 75,000
Elastic limit "M"	80,000 to 107,000	60,000 to 79,000
Ultimate strength "O"	89,000 to 135,000	113,000 to 130,000
Ultimate strength "M"	118,000 to 159,000	121,000 to 148,000
Elongation "O"	1.0% to 17.5%	11.0% to 16.0%
Elongation "M"	5.0% to 13.0%	5.0% to 12.5%
Reduction of area "O"	1.2% to 38.5%	19.4% to 29.2%
Reduction of area "M"	5.1% to 23.4%	3.5% to 20.1%
130-lb. R.E.		
Elastic limit "O"	68,000 to 91,000	59,000 to 74,000
Elastic limit "M"	74,000 to 90,000	64,000 to 75,000
Ultimate strength "O"	128,000 to 143,000	114,000 to 124,000
Ultimate strength "M"	125,000 to 138,000	101,000 to 128,000
Elongation "O"	13.0% to 18.0%	12.5% to 17.0%
Elongation "M"	7.0% to 15.0%	1.0% to 12.5%
Reduction of area "O"	25.7% to 39.8%	20.5% to 28.8%
Reduction of area "M"	6.3% to 28.5%	1.6% to 17.9%

6. We have had no transverse fissures reported in intermediate manganese rail.
7. One split head has been reported in the 130-lb. intermediate manganese rail.
8. We have no modifications or additions to specifications for intermediate manganese rail under consideration.
9. Our intermediate manganese rail has only been in track two years and with our relatively light business we are as yet unable to detect any appreciable difference in the intermediate manganese rail and the standard rail.

On Exhibit D the heats of standard chemistry as shown in comparison with the intermediate manganese heats were taken at random from rail rolled in the same year, while Exhibit E includes all of the standard composition rail rolled at Gary in 1926, and while the results obtained from the intermediate manganese rolling are interesting, and indicate that rail rolled to this specification is entirely satisfactory, we do not believe that the tonnage is large enough for the comparison between the two specifications to be more than indicative.

Pennsylvania Railroad Company (942 tons)

5. Percentage of first quality rails accepted..................91.1%
Percentage of second quality rails accepted................ 8.9%
Percentage of X-Rayls to all rails rolled.................. 1.6%
Percentage of rejection to all rails rolled..................26.5%
No X-Rayls shipped.
Did not make any fatigue tests.
No segregation tests nor tensile tests were made on the steel at the time of manufacture, but two of the failed samples which were sent to the Test Department, Altoona, for investigation did not show excessive segregation. The greatest negative carbon segregation reported was 9.79 per cent at M location.

Tensile tests made on the same two samples showed the average results to be as follows:

Elastic limit in lb. per square inch	77,560
Ultimate strength in lb. per square inch	132,750
Elongation per cent in 2 inches	11.75
Reduction of area, per cent	21.76
Brinell hardness	286

As we did not make tensile tests on the standard rail we are unable, therefore, to show a comparison.

6. No transverse fissures were reported.

7. As regards failures, there have been 101 to March 1, 1928 (28 months); 98 of these were head failures and three broken rails. The head failures were in the nature of split heads, and the faces of the splits indicated that they had developed in rapid detail-fracture formation from some pre-existing structural irregularity in the interior of the head. Previous investigations have tended to establish that these defects are produced by some thermal or cooling condition during manufacture. They were distributed among nine heats as follows:

Heat Number	*A*	*B*	*C*	*D*	*Unknown*	*Total Failures*
212329	..	3	7	5	..	15
213311	..	1	7	3	..	11
204309	2	11	11	8	..	32
206299	..	6	3	8	..	17
208312	..	..	5	7	1	13
206298	1	1	..	2	..	4
210281	1	..	1	..	..	2
207272	..	1	2	2	..	5
208311	1	..	..	..	1	2
Total	5	23	36	35	2	101

8. We have prepared no specifications for intermediate manganese rail, and might add that we do not contemplate the preparation of such specifications at this time.

The above rails were manufactured for us under the D. L. & W. R. R., modified as to manganese and carbon limits.

9. Results obtained from the service trials:

(a) Results of abrasive measurements show practically no difference in wear between intermediate manganese and ordinary open hearth, and what difference there was, was slightly in favor of the ordinary open hearth rails.

(b) Rail end batter and chipping not reported.

(c) During the first 14 months in service the rate of failures of intermediate manganese rails was 1,736 per 100 miles of track, while no failures occurred in the ordinary open hearth rail with which comparison is being made, and in the subsequent 14 months, or up to March 1, 1928, the rate of failures of intermediate manganese rail was 325 per 100 miles of track.

The extremely high failure rate of intermediate manganese rail in the early part of service trial is due in all probability to two heats which were high in manganese and at upper limit in carbon.

Approximation of Traffic Density

Record of tonnage passing over each stretch of track where intermediate manganese rail was placed in service, from October 1, 1925, to October 1, 1926:

Location of Tests

Pittsburgh Division

Track		*Tons*
No. 1	Between Milepost 241 and Milepost 243	63,214,933
No. 1	Between Milepost 244 and Milepost 248	63,214,933
No. 1	Between Milepost 253 and Milepost 255	65,585,725
No. 1	Between Milepost 266 and Milepost 268	59,987,890
No. 1	Between Milepost 270 and Milepost 272	59,987,890
No. 1	Between Milepost 274 and Milepost 275	50,498,000
No. 1	Between Milepost 296 and Milepost 299	34,866,290
No. 4	Between Milepost 322 and Milepost 324	24,857,334

Conemaugh Division

E.B.	Between Milepost 27 and Milepost 28	26,737,500
E.B.	Between Milepost 29 and Milepost 30	26,737,500
E.B.	Between Milepost 36 and Milepost 38	25,220,200

10. Results of the service trial thus far clearly indicate that we have not obtained satisfactory results from steel within the range of carbon and manganese under which this rail was manufactured.

Reading Company (300 tons)

5. Results of Inspection and Tests:

(a) Drop tests. All satisfactory.

(b) Exhausted ductility.
Varied from 48 to 50%.

(c) Deflection on 1st blow.
Minimum .70
Maximum .90

(d) Segregation tests.
All fractures were clear.
(e) Ball indentation tests.
2.1, 3.0 and 2.5.
(f) Percentage of X Rails.
Not so marked.
(g) Percentage of piped rails.
0.4%.
(h) Percentage of second quality rails.
2.4%.
(i) Fatigue tests.
Not made.
(j) Tensile tests.
Ultimate strength, 105,300 lb. per sq. in.
106,900 lb. per sq. in.
120,900 lb. per sq. in.
Elongation per cent
in two inches. 8.0, 12.0, 7.0.
Reduction of area 8.7%, 14.0%, 6.6%.

6. Transverse Fissures reported.
One after one year's service in main line track on curve under heavy traffic.
7. Head failures.
None.
8. Modifications or additions to specifications.
None.
9. Results obtained in service.
(a) Wear on curves.
Poor, inferior to rails purchased under standard specifications.
(b) Rail end batter and chipping.
Poor, not equal to standard rail.
(c) Rate of failures.
Very few failures occurred, due to the fact that carbon content was so low that the rails failed to sustain heavy traffic to which they were subjected and were removed from the track after two years' service. The traffic tonnage over these rails was between 35 and 40 million tons per year.
10. Further information.
Judging from our limited experience with so-called intermediate manganese rail it would appear that in order to obtain rail which will give good service under our traffic conditions we require more than the additional manganese. In fact it has been our experience that unless the rail contains above a .70% carbon it mashes down and flows over very quickly under our traffic.

The Committee recommends that the foregoing information be accepted and printed in the Proceedings as information.

Exhibit A

QUESTIONNAIRE ON INTERMEDIATE MANGANESE RAIL

1. Tonnage Purchased
   By Mills, Years, Sections and Weights per Yard.
2. Carbon limits specified.
3. Manganese limits specified.
4. Any other requirements which deviate from your standard specifications for ordinary Open Hearth rail.
5. Results of inspection and tests, giving specific information regarding results of tests as compared with ordinary open Hearth rail as follows:
   - (a) Drop tests.
   - (b) Exhausted ductility.
   - (c) Deflection on 1st blow.
   - (d) Segregation tests.
   - (e) Ball indentation tests.
   - (f) Percentage of X-Rails to all rails accepted.
   - (g) Percentage of piped rails to all rail accepted.
   - (h) Percentage of second quality rails to first quality rails accepted.
   - (i) Fatigue tests.
   - (j) Tensile tests.
6. Have any transverse fissures been reported in Intermediate Manganese rail? If so, give details.
7. Have any head failures been reported in Intermediate Manganese rail? If so, give number and type.
8. Have you any modifications or additions to specifications for Intermediate Manganese rail under consideration? If so, give details.
9. Results obtained in service from Intermediate Manganese rail as compared with ordinary Open Hearth rail.
   - (a) Wear on curves.
   - (b) Rail end batter and chipping.
   - (c) Rates of failure.

   If available, show approximate traffic density at location of tests in ton miles of revenue freight per mile of track or by some other convenient measure of traffic density such as trains per day, etc.
10. Any further information which you think would be of general interest on the subject.

Exhibit B

INTERMEDIATE MANGANESE RAIL

(1) Tonnage Purchased by Mills, Years, Sections and Weights per Yard. (2) Carbon Limits Specified. (3) Manganese Limits Specified. (4) Other Special Requirements.

(1) *Tonnage Purchased by Mills, Years, Sections and Weights per Yard*	*A.T.&S.F. Gr. Tons*	*C.B.&Q. Gr. Tons*	*D.L.&W. Gr. Tons*	*N.Y.C. Gr. Tons*	*Nor. Pac. Gr. Tons*	*Penna. Gr. Tons*	*Reading Gr. Tons*	*Total Gr. Tons*	
Bethlehem Steel Co.—Steelton									
1924 118-lb. DLW			287					287	
1925 105-lb. NYC				300				300	
1925 118-lb. DLW			2,626					2,626	
1925 130-lb. DLW			11,673					11,673	
1926 105-lb. DLW			4,332					4,332	
1926 130-lb. DLW			11,495					11,495	
1927 105-lb. DLW			4,669					4,669	
1927 130-lb. DLW			16,080					16,080	
1928 130-lb. DLW			20,000					20,000	
									71,462
Bethlehem Steel Co.—Lackawanna									
1926 105-lb. NYC				2,500				2,500	
1926 127-lb. NYC				1,500				1,500	
1927 105-lb. NYC				6,000				6,000	
1927 127-lb. NYC				5,000				5,000	
1928 105-lb. NYC				10,000				10,000	
1928 127-lb. NYC				12,600				12,600	
									37,600
Carnegie Steel Co.									
1925 130-lb. RE							300	300	
1925 130-lb. PS						942		942	
1926 115-lb. NYC				1,000				1,000	
1927 115-lb. NYC				2,500				2,500	
1928 115-lb. NYC				3,175				3,175	
									7,917
Illinois Steel Co.—Gary									
1926 90-lb. RA-A		2,000						2,000	
1926 100-lb. RE					953			953	
1926 105-lb. NYC				2,500				2,500	
1926 127-lb. NYC				1,500				1,500	
1926 130-lb. RE					752			752	
1927 90-lb. RA-A		2,500						2,500	
1927 100-lb. RA-A		5,200						5,200	

Illinois Steel Co.—Gary—(Concl'd)	*A.T.&S.F. Gr. Tons*	*C.B.&Q. Gr. Tons*	*D.L.&W. Gr. Tons*	*N.Y.C. Gr. Tons*	*Nor. Pac. Gr. Tons*	*Penna. Gr. Tons*	*Reading Gr. Tons*	*Total Gr. Tons*	
1927 105-lb. NYC	......	......	......	1,500	......	......	......	1,500	
1927 110-lb RE	......	3,900	......	......	......	......	......	3,900	
1927 127-lb. NYC	......	......	......	10,000	......	......	......	10,000	
1928 90-lb. RA-A	......	2,000	......	......	......	......	......	2,000	
1928 100-lb. RA-A	......	10,400	......	......	......	......	......	10,400	
1928 105-lb. NYC	......	......	......	5,000	......	......	......	5,000	
1928 110-lb. RE	......	7,100	......	......	......	......	......	7,100	
1928 127-lb. NYC	......	......	......	17,400	......	......	......	17,400	
									72,705
Inland Steel Co.—Indiana Harbor									
1926 110-lb. RE	......	1,000	......	......	......	......	......	1,000	
1927 90-lb. RA-A	......	1,200	......	......	......	......	......	1,200	
1927 100-lb. RA-A	......	3,200	......	......	......	......	......	3,200	
1927 110-lb. RE	3,000	1,900	......	......	......	......	......	4,900	
1928 100-lb. RA-A	......	7,300	......	......	......	......	......	7,300	
1928 105-lb. NYC	......	......	......	775	......	......	......	775	
1928 110-lb. RE	......	3,000	......	......	......	......	......	3,000	
									21,375
Colorado Fuel & Iron Co.—Pueblo									
1927 90-lb. RA-A	......	2,500	......	......	......	......	......	2,500	
1928 90-lb. RA-A	......	5,500	......	......	......	......	......	5,500	
1928 90-lb. S.Fe	1,000	......	......	......	......	......	......	1,000	
1928 110-lb. RE	9,000	......	......	......	......	......	......	9,000	
									18,000
	13,000	58,700	71,162	83,250	1,705	942	300		229,059
(2) *Carbon Limits Specified*									
90-lb.	0.50–0.65	0.50–0.65	......	......	......	......	......		
100-lb.		0.50–0.65	......	......	0.50–0.65	......	......		
105-lb.	......	......	0.54–0.67	0.54–0.67	......	......	......		
110-lb.	0.50–0.65	0.55–0.70	......	......	......	......	......		
115-lb.	......	......	......	0.54–0.67	......	......	......		
118-lb.	......	......	0.54–0.67	......	......	......	......		
127-lb.	......	......	......	0.54–0.67	......	......	......		
130-lb.	......	......	0.57–0.70	......	0.55–0.70	0.55–0.70	......		
(3) *Manganese Limits Specified*									
All weights	1.30–1.60	1.30–1.60	1.20–1.50	1.30–1.60	1.30–1.60	1.40–1.70	......		
(4) *Other Special Requirements*									
Letters IM hot stamped next to heat number	Yes	Yes	......	Yes	......	......	......		
Top of each ingot covered with graphite (1928 rolling)	Yes	......	......	......	......	......	......		

Exhibit C

DELAWARE, LACKAWANNA & WESTERN RAILROAD

WEAR ON 130-LB. MEDIUM MANGANESE RAIL

	Laid	*Sec.*	*Gross Tons*	*Wear per Million Tons*
Water Gap—E.B. Tang.	4-25	6-28	63,222,000	Left rail .0014 Right rail .0025
Stroudsburg—E.B. Tang.	11-25	6-28	51,216,000	Left rail .0012 Right rail .0014
Stroudsburg—E.B. Tang.	6-27	6-28	18,600,000	Left rail .0023 Right rail .0022
				Average .0018
Elmhurst—W.B. 5°00′ C.	5-26	11-27	20,416,200	High rail .0057 Low rail .0067
Henryville—W.B. 4°00′ C.	12-25	11-27	25,433,000	High rail .0056 Low rail .0057
Stroudsburg—E.B. 6°00′ C.	11-25	11-27	41,820,100	High rail .0041 Low rail .0043
Water Gap—E.B. 7°00′ C.	4-25	11-27	53,726,000	High rail .0079 Low rail .0059
				Average of four high rails .0058 Average of four low rails .0057

WEAR ON 105-LB. OPEN HEARTH RAIL

	Laid	*Sec.*	*Gross Tons*	*Wear per Million Tons*
Elmhurst—W.B. Tang. B.O.H	1-21	4-23	26,923,000	Left rail .0054 Right rail .0065
Nicholson—E.B. Tang. L.O.H	11-15	7-22	119,371,000	Left rail .0030 Right rail .0032
				Average .0045
Paterson—E.B. 1°30′ B.O.H. 118-lb.	1-24	4-26	45,859,000	High rail .0025 Low rail .0029
M.P. 130—W.B. 5°24′ C. L.O.H. 105-lb.	8-20	11-23	50,339,000	High rail .0107 Low rail .0113
May-Aug—W.B. 5°00′ B.O.H. 105-lb.	3-15	5-20	85,363,000	High rail .0070 Low rail .0070
Water Gap—E.B. 7°00′ C. P. O. H. 101 lb.	7-11	7-13	43,200,000	High rail .0080 Low rail .0082
				Average of four high rails .0071 Average of four low rails .0074

Exhibit D

NORTHERN PACIFIC RAILWAY COMPANY

Comparison of Intermediate Manganese and Standard Rail

Specification	*Section*	*Heat No.*	*Mill Analysis* C	*Mill Analysis* Mn	*Deflection First Blow*	*Exhausted Ductility, Per Cent*	*Broke on Blow No.*	*Ball Indentation Diameter*	*Yield Point* "O"	*Yield Point* "M"	*Ultimate Strength* "O"	*Ultimate Strength* "M"	*Red. Area, Per Cent* "O"	*Red. Area, Per Cent* "M"	*Per Cent Elongation* "O"	*Per Cent Elongation* "M"
A-3 Mod.	100-lb. RE	44031	.65	1.38	1.10	9.3	3	13.0 mm	80,310	79,250	128,800	117,900	24.4	21.9	13.5	13.0
	"	44032	.61	1.52	1.10	14.3	5	13.5 mm	.....	.....	......	......	...	...	...	...
Intermediate	"	45073	.65	1.72	0.95	9.8	4	12.0 mm	92,170	107,210	(*)	159,280	(*)	5.1	(*)	5.0
Manganese	"	48070	.57	1.48	1.20	11.3	4	13.0 mm	.....	.....	......	......	...	...	...	...
	"	48071	.57	1.40	1.30	12.7	5	13.0 mm	.....	.....	......	......	...	...	...	...
	"	49070	.65	1.54	1.15	13.8	5	13.0 mm	89,100	94,530	89,100	137,440	1.2	19.4	1.0	10.5
	"	50020	.56	1.29	1.15	13.0	5	13.5 mm	79,760	86,170	123,300	128,950	32.0	6.3	15.5	5.0
	"	51069	.59	1.40	1.15	11.2	4	13.5 mm	.....	.....	......	......	...	...	...	...
	"	51070	.59	1.76	1.10	12.3	4	13.0 mm	87,400	95,860	135,520	143,990	38.5	7.4	16.0	6.5
	"	52060	.53	1.48	1.10	11.6	5	13.5 mm	82,350	81,160	122,440	129,830	37.9	23.4	17.5	12.5
	"	53059	.57	1.42	1.15	13.7	5	13.5 mm	.....	.....	......	......	...	...	...	...
	"	54057	.60	1.42	1.10	10.2	4	13.0 mm	.....	.....	......	......	...	...	...	...
	"	55063	.59	1.76	0.95	11.2	5	13.0 mm	82,560	91,610	131,910	137,650	37.3	20.1	16.5	10.0
	"	56053	.56	1.44	1.10	9.0	4	13.0 mm	.....	.....	......	......	...	...	...	...
A-2 Mod.	100-lb. RE	66032	.64	.71	1.00	12.5	4	14.0 mm	.....	.....	......	......	...	...	...	...
	"	67262	.68	.66	1.25	12.7	4	13.5 mm	.....	.....	......	......	...	...	...	...
Ordinary	"	53271	.68	.72	1.25	13.5	4	13.5 mm	.....	.....	......	......	...	...	...	...
Open Hearth	"	61288	.76	.77	1.10	9.5	4	13.0 mm	.....	.....	......	......	...	...	...	...
	"	68270	.76	.85	1.05	10.5	4	13.0 mm	.....	.....	......	......	...	...	...	...
	"	45314	.75	.63	1.25	11.3	4	13.5 mm	.....	.....	......	......	...	...	...	...
	"	46318	.70	.63	1.25	11.5	4	13.5 mm	.....	.....	......	......	...	...	...	...
	"	54264	.62	.67	1.35	13.3	4	14.0 mm	.....	.....	......	......	...	...	...	...
	"	67263	.69	.80	1.20	11.3	4	13.5 mm	.....	.....	......	......	...	...	...	...
	"	44299	.70	.74	1.20	11.6	4	13.5 mm	.....	.....	......	......	...	...	...	...
	"	36288	.67	.73	1.15	11.2	4	13.5 mm	.....	.....	......	......	...	...	...	...
	"	35266	.66	.70	1.15	11.3	4	13.5 mm	.....	.....	......	......	...	...	...	...
	"	38312	.68	.76	1.20	12.0	4	14.0 mm	.....	.....	......	......	...	...	...	...
	"	55287	.68	.77	1.20	11.5	4	13.5 mm	.....	.....	......	......	...	...	...	...
	"	50266	.75	.77	1.05	9.8	4	13.0 mm	.....	.....	......	......	...	...	...	...
	"	47284	.63	.68	1.30	13.0	4	14.0 mm	.....	.....	......	......	...	...	...	...
	"	53273	.68	.80	1.05	8.9	4	14.0 mm	.....	.....	......	......	...	...	...	...
	"	52292	.64	.75	1.25	11.8	4	13.5 mm	.....	.....	......	......	...	...	...	...
	"	44300	.67	.76	1.20	11.0	4	13.5 mm	.....	.....	......	......	...	...	...	...
Average—Mod. Mn.Rail			.59	1.50	1.11	11.6			84,813	90,827	121,845	136,434	28.5	14.8	13.3	8.9
Average—Std. Mn. Rail			.68	.73	1.18	11.5			No figures available.							

* "O" broke outside gauge marks.
Sept. 28, 1928

Exhibit E

NORTHERN PACIFIC RAILWAY COMPANY

Comparison of Intermediate Manganese and Standard Rail

	No. of Heats	*No. of Rails*	*Accepted*	*Re-jected*	*X-Rayls*	*Piped*	*Second Quality*	*First Quality*
Inter. Mang...	14	1,779	1,731	48	263	14	74	1,394
Stand. Mang..	315	39,887	39,246	641	986	91	2,953	36,293

	Int. Mn.	*Std. Mn*
Percentage of X-Rayls to all accepted	15.2	2.5
Percentage of piped rails to all accepted	16.01	2.73
Percentage of second quality to first quality accepted	4.5	8.1

DISCUSSIONS

DISCUSSION ON STANDARDIZATION

(For Report, see pp. 65-121)

Chairman W. C. Cushing (Pennsylvania):—STANDARDS AND PURCHASING: There are few persons responsibly associated with large-scale buying and supplying who are not agreed upon the importance of employing standards in their negotiations in order to provide the foundation for competition by sellers and the means by which uniformity can be secured in the quality of the product. But the importance of employing standards that are uniform and of adhering to them in practice does not seem to be so well recognized. A road will go to expense and trouble to establish a standard to govern the manufacture of a commodity in the open market which will embody some deviation from that adopted by some other road often just enough to avoid interchangeability, with the result that competition is thereby restricted to the few producers who have templets ready, or the cost is higher than it would be if mass production could be secured.

To establish a standard, moreover, which purports to be the going standard in a particular branch of business and then fail to adhere to that standard in purchasing, is as destructive of economy in buying as a failure to adopt a uniform standard. Railways, it seems, have been particularly remiss in recognizing this in their lumber buying, although the principle applies equally to other lines of purchasing. It is often recited how a lumber buyer will advertise for prices on a certain grade of lumber and award the business to the lowest bidder, and subsequently learn that if the higher bidders had known when offering prices that the buyer would actually accept a lower grade lumber than specified, that grade could have been secured at a much lower price even than was offered by the low bidder who had reaped the advantage of his knowledge of the buyer's practice. Thus it frequently develops in the railway business that competition is not what it could be and prices are not what they should be, simply because the railroads themselves fail to adopt or to follow fundamental principles.

The value of standards to efficient purchasing has been proved beyond a doubt, but it still remains to be proved that a buyer who does not support the practices which standardization calls for can be depended upon to get the best end of the bargain.

Your attention is directed to pages 73 and 74 of the report, quoting the Department of Commerce letter in which the A.R.A. was requested to designate a representative to attend a meeting to consider the question of international agreement on the standard temperature for intercomparison of industrial standards of length.

This meeting was not held, as it was found that the matter could be adequately handled by correspondence.

With the acquiescence of a large number of manufacturers and users of gages, gage blocks, etc., and the unanimous opinion that 20 degrees C. (68 degrees Fahr.) was the most satisfactory temperature for this purpose, a report was prepared and submitted to the International Committee recommending the adoption and use of that temperature for all industrial standards of lengths.

Although final action was not taken, the Bureau of Standards considers there is reasonable possibility that it will be approved.

I am now informed by Dr. Burgess that the purpose for which the committee was formed has been accomplished and the committee may, therefore, be considered as discharged. The occasion for an official delegate on the part of the American Railway Association has, therefore, ceased and determined.

"The International Temperature Scale.—The International Committee of Weights and Measures in 1927, the Seventh General Conference representing 31 nations, accepted provisionally and for further study the International Temperature Scale submitted jointly by the Bureau of Standards, National Physical Laboratory and Physikalisch-Technische Reichanstalt, and, therefore, the Bureau of Standards, in common with other national laboratories, will use until further notice in its scientific work, and for the calibration of instruments, the standard temperatures, interpolation formulæ, and methods of measurement as laid down by the General Conference of Weights and Measures on October 4, 1927. It is recommended that scientific workers elsewhere conform to the International Temperature Scale. It will be found in Bureau of Standards Journal of Research, Vol. 1, No. 4, October, 1928, page 635."

A main object of the report of this Committee for this year is to bring out the necessity for industrial management to foster the work of standardization and keep it in its own hands. In argument, therefore, the report presents public sentiments by the recent President of the United States and the new President of the United States, both emphasizing their beliefs that Government must be kept out of business.

I move the adoption of the report.

The President:—Is there any discussion of the report?

(The motion was put to a vote and carried.)

The President:—Mr. Cushing advises me that that completes the report. The Association thanks him and his Committee for the work they have done, and as customary, they are discharged with the thanks of the Association. (Applause.)

DISCUSSION ON WATER SERVICE AND SANITATION

(For Report, see pp. 123-209)

Chairman C. R. Knowles (Illinois Central) :—The report of the Committee on Revision of the Manual appears under Appendix A. The Committee has no additional matter to submit at this time for inclusion in the Manual. Work for the past year has consisted of study of the subject-matter with a view of determining what revisions or additions should be made. We have also assisted in the arrangement of the material to be included in the new Manual.

The Committee is now engaged in the work of revision of forms used by the water department, complete specifications for laying cast iron pipe, and certain definitions applying to water service.

The report of the Sub-Committee on the Causes and Extent of Pitting and Corrosion of Locomotive Boiler Tubes and Sheets appears on page 133. This Committee has attempted to assemble and co-ordinate general information on this subject; included in the report are some very excellent photographs of metal and corroded areas of boilers. Mr. O. T. Rees, Chairman of the Sub-Committee, will present this report.

Mr. O. T. Rees (Atchison, Topeka & Santa Fe) :—Our investigations have developed that specifications on the metals used in boiler construction are mostly of recent adoption, and numerous tests of various kinds are still in progress to determine whether or not metals of higher resistance to corrosion can be found for this purpose.

In the past numerous cases of serious corrosion on tubes and sheets have developed due to defects in the metal caused by faulty processes in the manufacture, or in the fabrication of the metal in boiler construction, causing undue stresses to localize at certain points. Manufacturers must improve their processes to overcome these defects and users must eliminate the defective material by more rigid specifications and inspections. And in the designing of locomotive boilers careful consideration should be given to reduce as far as possible all undue strains.

In our study of the various types of water which seem to accelerate corrosion to the greatest degree are those which contain quite a considerable amount of the magnesium salts and those low in solids, but which have a high hydrogen ion concentration.

Waters carrying high concentration of magnesium salts should be eliminated as sources of supply if possible, and where this is impossible the water should be so treated as to remove as much of the magnesium as is possible before the water enters the boiler, and sufficient excess causticity maintained to neutralize any dissociation of unremoved magnesium salt.

Those waters carrying a high hydrogen ion concentration must be treated with some alkaline material whereby the hydrogen ion concentration is reduced.

Gases held in solution by a boiler feedwater have an effect upon the amount and rate of corrosion, but this can be largely eliminated by use of proper equipment for their removal.

No reliable data appears to be available regarding the effect on corrosion of any of the materials used in the numerous boiler compounds now on the market.

It has been noted by some of the roads who store engines that considerable corrosion takes place during these periods, but all are not agreed as to the best method for preventing it. It is quite important that this subject be given further consideration.

I move the adoption of the report.

The President:—Is there any discussion on any part of the report?

(The motion was put to a vote and carried.)

Chairman C. R. Knowles:—The next report of the Committee appears under Appendix C-1, and covers the discussion of methods of treatment of boiler waters of low hardness.

The second part of this Sub-Committee's report appears as Appendix C-2, and is an excellent review of the progress in water treatment on railroads and on the possibilities of future development. Dr. Koyl is Chairman of this Sub-Committee and will present the report.

Dr. C. H. Koyl (Chicago, Milwaukee, St. Paul & Pacific):—The first question asked us was for a report on methods of water treatment where complete lime and soda ash treating plants cannot be justified, or pending their construction.

Appendix C-1 consists of a brief review of the methods in common use for the improvement of boiler water, a statement of the kind of water to which each method is most applicable, and an effort to prove that there is no such thing as a "prohibitive cost" for water improvement, because the damage done to railroad revenues *by the use* of unsuitable boiler water is always several times the cost of extracting the obnoxious matter, whether the amount be large or small.

Your attention is directed to the lower part of page 134, and the paper of S. C. Johnson of the Chesapeake & Ohio Railway, with its demonstration of the damage done by waters of only 5-grains-per-gallon hardness if even a fraction of one grain of this be sulphate. There are few better boiler waters in the country than those cited by Mr. Johnson, and from his paper an idea can be gathered of the necessity for expert study of the subject by all railroads.

This Committee has been requested several times to determine the lowest degree of hardness in a water which will justify complete treatment with lime and soda ash, and we have been unable to answer because it is evident that the point is getting lower every year. This comes of the increasing realization that the cost of coal and boiler repairs is only part of the cost affected by unreliability in the boilers, and when all the costs are added it is seen that the best of water is none too good and that there are few natural waters which are not improved by some form of treatment.

For those who wish a simple method for calculating from its analysis the probable damage in coal and boiler repairs of *using* any particular water, the following will suffice: Our oft-repeated and oft-proved statement that 1000 gallons of water of 7-grains-per-gallon hardness deposits scale which costs 14 cents to remove means that each grain per gallon hardness costs 2 cents per thousand gallons to remove.

This question has been asked us in various forms every year for many years, and we think that this is the simplest method which we can suggest for those who are not accustomed to all the details of water study. Every grain of hardness in the water costs, on the average, 2 cents per thousand gallons to remove. This method may be used with assurance if the cost is understood to cover only coal and boiler repairs, if the incrusting matter is nearly all carbonate hardness, and if the result is considered a minimum.

If any large proportion of the hardness should be sulphate hardness, the cost is always considerably more than 2 cents per thousand gallons. That is our answer to the first question.

The second question is a request to review progress in water treatment on railroads and report on possible future development.

Appendix C-2 contains an outline of the history of water softening since 1840 and of its application to railroads in the United States. It is merely an outline which we hope to elaborate this year by including the work on Canadian railroads and more details for the United States.

As the story appears in Bulletin 310, it has a blemish because the printer omitted a page of manuscript which should have preceded line 19 on page 140. This paragraph recited the first two attempts at water softening on American railroads, one on the Oregon Short Line Branch of the Union Pacific in December, 1891, and the other on the Southern Pacific at Port Los Angeles in December, 1896. This omission will be remedied in the Proceedings.

The balance of the paper is such information as we have been able to gather concerning the installation of water softening plants on railroads, and which we hope to extend this year so as to include very much more than it does now.

Chairman C. R. Knowles:—It is moved that this report be received as information and the subject be reassigned to the Committee for further study and report.

Mr. J. L. Campbell (Northwestern Pacific):—Dr. Koyl made the statement that whatever the cost of treating the water, it is justified. About twenty years ago, on one engine district of the El Paso and Southwestern Railroad in New Mexico, we cured an exceptionally bad water situation by bringing in a new supply of good water from the high mountains by pipe line 140 miles long, at a cost of $1,000,000. The resulting reduction in operating expenses returned all of the $1,000,000 to the company in two years.

Dr. C. H. Koyl:—Mr. Chairman, the work which Mr. Campbell has just referred to is one of the classics of the art. There never could have been a better demonstration of the cost of using bad water. Mr. Campbell says that the deep well waters they were unable to soften without making them foam so bad that they could not be used in the boilers. Of course there are some waters as bad as that. But the remedy in such a case is just what Mr. Campbell did. If you cannot get suitable water near the railroad you will know that the expense will always be justified in bringing water from a distance. The most expensive thing that can be done on a railroad is to use bad water in a boiler.

(The motion was put to a vote and carried.)

Chairman C. R. Knowles:—The next Sub-Committee report appears on page 143 and is a report on Study of Protective Coatings for Interior of Steel Tanks and Underground Pipe Lines. The Committee has gone into this subject very thoroughly, and while it is not the thought of the Committee that the subject has been exhausted, we feel that the report embodies all of the information available at the present time. We may perhaps ask the Committee on Outline of Work to give us a further assignment at some future date when further information is available.

Mr. J. H. Davidson is Chairman of this Sub-Committee and will present the report.

Mr. J. H. Davidson (Missouri-Kansas-Texas):—The problem of protecting the interior of steel water tanks from corrosion presents a great many difficulties. This is also true of the protection of underground pipe lines. The information which this Sub-Committee obtained from roads all over the country indicates that very few roads have what they consider satisfactory methods of handling this class of work.

The report which appears in Bulletin 310 contains and describes methods of handling this work, and presents some ideas which can no doubt be profitably followed, and should prove of value to those who supervise this work.

As Mr. Knowles just told you, this cannot be considered a final report in any respect, because there are new developments coming up in regard to protective coatings every day. There are some protective coatings on the market that seem to have very good possibilities, but they have not been used long enough so that we can make any definite recommendations.

What we present here is just an outline to give the members an idea of some of the lines along which it might be possible to make improvements in taking care of this class of work.

Chairman C. R. Knowles:—It has been moved that this report be received as information.

(The motion was put to a vote and carried.)

Chairman C. R. Knowles:—The next report of the Committee appears under Appendix E, and deals with the study and report on Incrustation in Pipe Lines and Methods of Prevention, particularly where treated water is used.

Mr. E. M. Grime is Chairman of this Sub-Committee and will present the report.

Mr. E. M. Grime (Northern Pacific):—This report shows that incrustation of pipe lines is very largely due to the residual hardness present in waters which have been softened by the standard lime-soda cold water process.

From a study of conditions in various parts of this country three typical examples of pipe line incrustation are cited and four conclusions are drawn, which may be briefly summarized as follows:

1. Softening of water to reduce the hardness to one grain or less will reduce pipe line incrustation to the minimum, if not entirely prevent it.

2. Recarbonization of water to prevent after-precipitation is generally not advisable in railroad practice.

3. As far as practicable, it is best to avoid long pipe lines for conveying treated water.

4. Cleaning of incrustated lines can be readily accomplished by the mechanical method of passing some scraping device through the line, or in the case of small lines the cleaning may be accomplished by pumping hydrochloric acid through the pipe until the incrustants are completely dissolved.

Chairman C. R. Knowles:—It is moved that this report be received as information and accepted as a final report.

(The motion was put to a vote and carried.)

Chairman C. R. Knowles:—The next report covers the Use of Gravity and Pressure Filters. In the opinion of the Chairman this is a complete and comprehensive report on the use of filters in railway water service. Mr. D. A. Steel is Chairman of the Sub-Committee and will present the report.

Mr. D. A. Steel (Railway Age):—When the Committee was assigned this subject it was understood to be a subject on which differences of opinion existed in the Committee, some of those operating filters having become dissatisfied with the results and holding more or less to the opinion that filters were useless; other members of the Committee going so far as to advocate the use of filters not only for filtration purposes but claiming a slight softening action for them as well.

In addition to these differences in the Committee it was noted there were differences among other members of the Association. Last year after the work was assigned, the Chairman of your Committee met Mr. Ford of the Rock Island and Mr. Yager of the Northern Pacific in the lobby of this hotel. Mr. Ford represents a railroad that does a great deal of water conditioning and uses no filters, while Mr. Yager represents a road that is going strongly into water treatment and is quite interested in filtration.

The Committee had the problem on its hands of producing information that would be acceptable, and at the same time reconcile the striking differences of opinion that could be expected to exist in the Association.

For that reason the Committee has interpreted its assignment broadly by confining its report not only to the use of gravity and pressure filters, but trying to give the railway engineer a picture of the whole field of filtration, in order that he can see how the gravity and pressure filters fit into the general scheme.

We believe that the Committee has presented a report which will be a useful reference work for the engineer who is caught short of time and wants to get workable, practical information on the subject.

It presents some historical matter in order to show the evolution of filtration. It presents material which will afford the engineer the high points of filtration in case he might be investigating the subject.

It affords him material which will be useful in preparing specifications for the installation of filtration units, and also important information about how filters must be operated.

A distinctive feature of the Committee's report this year is the tabulation of information secured by questionnaire from several roads giving the kind and type of filters on several roads, with their number, cost and a report of the results obtained. Supplementary to that information and by way of amplifying it, the Committee is also presenting what it considers to be the first compilation of vital water statistics. Several roads are listed, with the number of water stations on each, annual pumpage of untreated and treated water, number of wayside softening plants and number of filters in use.

This table ought to be enlarged upon. The Committee feels that eventually every railroad in the United States ought to be tabulated with reference to the water consumed, used, treated, and so forth, particularly because of the growing importance of good water.

The high points for the engineer, with reference to filtration, are contained in the conclusions. The main idea is that the engineer should keep in mind, in connection with filtration, that a filter is no cure-all, that effective filtration must be preceded by sedimentation and coagulation. Without this, filtration is apt to prove a disappointment.

The conclusions also give the Committee's opinion with reference to the relative merits of different kinds of filters, sand, excelsior, gravity and pressure for water service, and submit the report to the Association with the general conclusion that, regardless of the disappointments with some filters, on the whole, filtration deserves careful consideration as a refining process in assuring, under correct design, operation, and particularly maintenance of supervision, that the waters will be free from all the materials which clog the pipe lines and cause maintenance troubles for the engineer, but which also cause disturbances in boiler operation.

Chairman C. R. Knowles:—It is moved that this report be accepted as information and as a final report.

(The motion was put to a vote and carried.)

Chairman C. R. Knowles:—The report of the Committee on Fire Protection and Prevention at Water Stations appears under Appendix G and includes a discussion of some of the causes of these fires and recommendations as to their prevention. Mr. Willahan is Chairman of this Committee and will present the report.

Mr. A. E. Willahan (Kansas City Southern):—The first thing the Sub-Committee did was to find out how much property was involved. From statistics gathered from about 75 railroads we found that $44,000,000 out of $220,000,000 were liable to damage by fire.

We then tried to ascertain the conditions that were responsible for the damage. These are listed numerically from (1) to (8).

The fact that the first four conditions are responsible for about 90 per cent of the loss should be remembered. All of them are easily corrected. Faced with such large losses, with the remedy so simple, we can reach but one conclusion.

The recommendations, after a study of the conditions, are obvious, and we submit them for your consideration.

Chairman C. R. Knowles:—It is moved that this report be received as information and accepted as a final report.

Mr. Robert H. Ford (Chicago, Rock Island & Pacific) :—I should like to ask if the Committee complied with their instructions to confer with the Railway Fire Protection Association.

Chairman C. R. Knowles:—The Committee understood that that assignment had reference to the preparation of rules for fire prevention, Mr. Ford, and would be handled with the Committee on Rules and Organization and with the Fire Protection Association through that Committee, who will draft the final rules for inclusion in the Manual.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe) :—In looking over the list of rules for fire prevention given by the Committee, I was reminded of a newspaper article which I noticed during this past season. Out in the Middle West a river overflowed to such an extent that it flooded the pumping station. The pumping station took fire, and the pumper, who was marooned at that place, lost his life. The fire was supposed to have occurred due to the flooding of unslaked lime. Whether that is true or not, I do not know, but it was so reported.

It seems to me, among the other fire prevention measures, the Committee should recommend that a lime supply should not be stored in wooden buildings or adjacent to wooden buildings where it could cause fire.

Chairman C. R. Knowles:—The use of hydrated lime in water softening is so general that the Committee felt that those instructions were unnecessary. There are only one or two roads, if I am correctly informed, that use unslaked lime, and they fully realize the necessity for protecting that lime in storage against moistures. As a matter of fact, some of the roads (I think one is Mr. Baldridge's road) have a special arrangement for handling lime. It is elevated well above the ground in storage, so there is no possibility of moisture causing fires.

The President:—Is there any further discussion or questions on this Sub-Committee report?

Mr. J. A. Given (Southern Pacific) :—The Committee might use a special form of fire protection which we have on some parts of our railroad. For instance, I have in mind that on the division with which I am associated, we have five fire cars for protecting our tunnels, bridges, and fighting forest fires. These fire cars are 12,000-gallon tank cars, equipped with fire pumps, and may be operated either by steam or air from either end of the car.

In addition, there are ladders, axes and 1,000 feet of fire hose. We have found these cars very effective in fighting tunnel fires and especially forest fires.

The President:—Are there any further comments or suggestions or observations on this Sub-Committee report?

(The motion was put to vote and carried.)

Chairman C. R. Knowles:—The next report of the Committee appears as Appendix H. The subject as assigned to the Committee was to report on the Design and Maintenance of Trackpans for Locomotive Supply. Mr. McCaleb has prepared a very excellent monograph on the subject, which embodies the information obtained from extensive studies on the Pennsylvania System.

Mr. E. G. Lane, the Chairman of the Sub-Committee, is not present, but his Committee has assembled an immense amount of information which will include complete plans for design and construction of trackpans as well as certain information in connection with points where trackpans should be used and under what conditions they should be used.

The monograph is submitted as a progress report. It is moved that the subject-matter be reassigned to the Committee for further study.

The President:—Is there any discussion?

(The motion was put to vote and carried.)

Chairman C. R. Knowles:—The report of the Sub-Committee on Methods Used in Obtaining Successful Wells in Fine Sand Formation appears as Appendix I. Mr. J. R. Hickox is Chairman of this Sub-Committee and will present the report.

Mr. J. R. Hickox (Chicago, Burlington & Quincy):—A report on Methods Used in Obtaining Successful Wells in Fine Sand Formation will be found in Bulletin 310, Appendix I, page No. 182, with cuts illustrating the methods described for installing the wells.

The principle involved is to increase the area of the contact surface between the fine sand and the screening material so that when a given amount of water per minute is drawn from the well, the movement of the water leaving the sand will not be fast enough to move the fine sand. When this rate of flow for any particular well has been determined, the well should never be pumped in excess of this rate.

Chairman C. R. Knowles:—It is moved that the report be received as information and accepted as a final report.

The President:—You have heard the motion that we receive this as information and final report. Are there any questions or discussions?

(The motion was put to vote and carried.)

Chairman C. R. Knowles:—The report of the Sub-Committee on Study and Report on Water Columns, their Advantages Over Tank Delivery, Required Range of Operation, Type of Pit, and Relative Merits of Rigid and Telescopic Spouts, appears as Appendix J on page No. 187. Mr. J. P. Hanley is Chairman of the Sub-Committee and will present the report.

Mr. J. P. Hanley (Illinois Central):—The report is arranged under the subhead system and deals with the merits and demerits of water columns and tank spouts, the range of water column operation, type of water column pits, relative merits of the rigid and telescopic spouts, delivery capacity of water columns when supplied by mains of various sizes and lengths, photographs and plans of typical installations, and conclusions, which appear on page 194, and are intended to be a short summary of the entire report.

Chairman C. R. Knowles:—It is moved that this report be accepted as information and as a final report.

Mr. J. M. Farrin (Illinois Central):—On page 194 this Sub-Committee calls attention to tests made at the University of Illinois as between two different types of water columns, and on page 195 are shown the figures for the Mansfield spout and the U.S. spout. If you will take the discharge of 3000 gallons on a Mansfield spout you will find that the column causes a loss of 26 feet in head, whereas with the U.S. column of the same discharge only a 13-foot loss in head is caused.

In the report of the Committee on page 195 they have a table purposing to give the discharge through a 10-inch spout, that is, a 10-inch U.S. and Mansfield water column.

In view of the fact that there is a great difference in loss of head between the two water spouts, I do not see how they can be combined and not take into account the difference in loss of head in giving the discharges as shown in this table.

Chairman C. R. Knowles:—Mr. Farrin refers to the report as made by the University of Illinois some years ago. The two columns in question are made by the same manufacturer. As a result of the tests conducted at the University of Illinois, the columns were redesigned in order to secure the maximum flow and the minimum of interruption to flow through the two columns which gave approximately the same delivery.

These tables referred to are submitted as information, and it would probably be impossible to check the figures with any individual computation as they are an average of a great number of figures secured from tests made from time to time, and every figure given does not represent an actual test of water column delivery but is prepared on the basis of actual figures secured from these studies and tests and, as stated in the note below, is based on average used iron pipe and is subject to variation as to condition of supply mains; that is, as to number of bends, corrosion, incrustation, and even method of coating the interior of the pipe.

Mr. J. E. Teal (Chesapeake & Ohio):—I question the propriety of advertising a special device without giving consideration to other similar devices which may or may not give equal or better performance.

As far as the data on pages 195 to 200 is concerned, it seems to me this Association should not print such data unless it got similar information for all other types manufactured by other manufacturers. I believe it would be better to have such information published in the catalog of the manufacturer rather than in the Proceedings of this Association. I should like to offer a resolution that it be not published in the Proceedings.

The President:—Is that in the form of a motion?

Mr. J. E. Teal:—It is a motion.

The President:—Will you please restate your motion?

Mr. J. E. Teal:—That the tables shown on pages 195 to 200 of Bulletin 310 be not published in the Proceedings of the American Railway Engineering Association.

The President:—The motion is that this data be not published.

Mr. J. P. Hanley:—The tables under discussion were printed with the understanding that they would represent the flow of water columns of practically any manufacturer. The water columns of all the reputable manufacturers nowadays give approximately the same flow. It was thought by the Committee that under these conditions the information published would be convenient as a reference for many operating officials who are not engineers, and who are not in position to figure out curves and diagrams. For that reason it is my opinion that the tables shown are convenient and good information, and I believe they should be published in the Proceedings.

Mr. J. M. Farrin:—I think these tables give us a lot of information that is useful. It seems to me we could get around Mr. Teal's objection by omitting the name of the manufacturer. I think that is not necessary at all.

Chairman C. R. Knowles:—I question whether we could do that with propriety for the reason that this investigation has entailed a great deal of work and expense on the part of the manufacturers, and they were kind enough to even loan us the tracings which I believe saved us a matter of $150 or $200 for setting the matter up in type. Out of courtesy to the manufacturer we left their name on the tracings. It would have been entirely satisfactory to the manufacturer had we published the tables without their name.

As Mr. Farrin has said, the tables present so much practical information on the flow through water columns under average conditions that we felt they would be of value and the Committee feels they should be published as they appear in Bulletin 310.

The President:—Is there any further discussion? The motion which has been made and seconded is to delete these tables from the Proceedings.

(The question was called for, and the motion was lost.)

The President:—The retention has it, and they will be so retained.

(The motion to accept the report as information and as a final report was carried.)

Chairman C. R. Knowles:—The report of the Committee on Regulations Pertaining to Drinking Water Supply appears under Appendix K, page 201. The Chairman of this Sub-Committee, Dr. S. C. Beach, is not with us today, so I will state that the report is merely a review of such action as has been taken during the past year on the question of drinking water supply and refers particularly to the work of the Joint Committee composed of representatives of the A.R.E.A., the Mechanical Division of the A.R.A., and representatives of the U.S. Public Health Service.

This report is presented as information and it is recommended that the subject be reassigned to the Committee for further study.

The President:—Are there any objections? It is so ordered.

Chairman C. R. Knowles:—Appendix L simply has reference to the progress of work of the Committee. No report submitted.

The report of the Committee on Providing Drinking Water at Coach Yards, appears under Appendix M on page 202. Mr. C. M. Bardwell is Chairman of the Sub-Committee and will present this report.

Mr. C. M. Bardwell (Missouri-Kansas-Texas Lines):—The railroads of the United States have been required to go to considerable trouble and expense to supply drinking water of certified quality to their patrons on passenger cars. In this regard it should be the desire of the railroads not only to comply with the regulations but also to protect the health of their patrons as much as possible. Some of the effort to supply safe drinking water to passenger cars is of little avail on account of the possibility of contaminating the water in transporting it from the storage tank to the passenger coach.

Your Committee has endeavored to outline methods of handling and equipment which will minimize this chance of contamination in supplying drinking water to passenger cars, and sets forth its conclusions on page 206, Bulletin 310, Appendix M. The Committee submits this report as information.

Chairman C. R. Knowles:—It is moved that this report be received as information and the subject reassigned to the Committee for further study and report.

(The motion was put to vote and carried.)

Chairman C. R. Knowles:—If I may be permitted to refer again to the progress of the Sub-Committee appearing under Appendix L, Mr. W. B. McCaleb would like to make a few remarks in regard to the work of this Committee.

Mr. W. B. McCaleb (Pennsylvania):—Mr. Bardwell has very well expressed briefly the situation in which the railroads are with regard to adopting a suitable method of supplying drinking water. This matter has been before the railroads for a number of years but the committee representing the Health Department of the Government is now pressing the matter. Therefore, I am calling attention to Mr. Bardwell's remarks so that you may all be impressed with the importance of this question to the railroads. If we, the operating people, do not act, the Government will doubtless tell us what to do and may put some very burdensome requirements on the railroads.

The subject assigned this Sub-Committee is upon the Methods and Practices of Handling Water for Drinking Purposes. A preliminary draft of our final report will be submitted to the full Committee at their regular meeting next month for criticism, and your Sub-Committee will submit complete final report, ready for publication, at the October meeting of the full Committee.

We realize the importance to the railroads of securing and handling drinking and culinary water supplies. In preparing the report, therefore, every effort has been made to meet the obligation by giving the member railroads a simple statement of requirements, standards and recommended procedure. Our efforts have been directed in the report towards the laying of a foundation or groundwork by recording the federal requirements and procedure where they control; the characteristics of safe and satisfactory waters, and the relative importance of these characteristics, and finally stating in a general way the various demands to be satisfied.

In submitting the final report to the full Committee, definite suggestions will be made concerning desirable future sub-committee work of a definite, technical character on the various subjects discussed in our present report.

Chairman C. R. Knowles:—Thank you, Mr. McCaleb.

As indicated by the last three reports, in addition to the study of water supply, your Committee has been assigned to the study of railway sanitation, and I would call your particular attention to a monograph which appears as

Appendix N on page 207, entitled, "The Association's Opportunity for Promoting Railway Sanitation." In this monograph Mr. H. W. Van Hovenberg briefly outlines the scope of the work, and the Chairman joins him in soliciting the assistance of the members in developing this phase of the work.

That concludes our report.

The President:—Before excusing this Committee I wish to say that out of the 39 members on this Committee, 30 are present today. I also wish to say that this is one of the few if not the only Committee that has corresponding members in other countries. They have 15 corresponding members representing 15 different countries. Out of these 39 members there are 26 railroads and 14 states represented.

This report is of great interest and it is impossible for you to absorb it in this short length of time. This information should be read carefully after you leave.

I wish to express the thanks of this Association to this Committee. (Applause.)

DISCUSSION ON ROADWAY

(For Report, see pp. 211-243)

Chairman C. W. Baldridge (Santa Fe):—The Committee report will be found on page 211 of Bulletin 310. The subjects assigned to this Committee were sent to every member in the report last spring, and it is assumed that if you are interested you have already read them.

On page 212 we have given an outline of the action recommended, but as the action recommended will be repeated with each Appendix that is presented, we will defer the reading of the recommendations.

On page 213, Appendix A covers the Revision of the Manual. Mr. W. H. Woodbury, Chairman of the Sub-Committee, is not here today. I shall therefore read Appendix A.

"The lack of a definition of the term 'Grade' when used as a noun, has been called to the attention of the Committee, and to remedy that lack, the following definitions are offered:

"Grade (noun).—The ratio of rise, or fall, of the grade line to its length (computed in length of construction stations.)

"Sub-Grade (noun).—The finished surface of the roadbed before the application of ballast or track.

"Note.—The term 'Grade' is sometimes used to designate the finished roadbed, but such use conflicts with the meaning of 'Grade' as given above and it should not be so used.

"The Committee has no other revisions of the Manual to offer this year."

We therefore move that the two definitions given and the Note be adopted for inclusion in the Manual.

The President:—It has been moved and seconded that the definitions on page 213 be put in the Manual. I might state that it is hoped to get the

Manual in your hands by the last of the coming August. Is there any discussion on Appendix A?

(The motion was put to vote and carried.)

Chairman C. W. Baldridge:—Appendix B covers Deformation of Roadbed. Prof. Jamison Vawter, Chairman of the Sub-Committee, will present this report.

Prof. Jamison Vawter (University of Illinois):—This report gives a number of references to previous volumes of the Proceedings of the Association, going back as far as 1906, where studies have been made along the lines the Committee has been following. The Committee does not feel that it can add anything to its own or these other recommendations at the present time, and therefore recommends that the subject be discontinued for the present.

It is felt that the subject is an important one, but before further progress can be made toward definite recommendations the subject of certain maintenance costs should be assigned to the proper committee. An effort should be made to determine the cost of track maintenance for various depths of ballast and densities of traffic, also the depth and rate of penetration of the ballast into the sub-grade on recently constructed lines.

Chairman C. W. Baldridge:—The report of this Sub-Committee is offered for information with the recommendation that the subject be discontinued.

The President:—It will be so referred to the Committee on Outline of Work.

Mr. E. R. Lewis (Michigan Central):—I am disposed to urge that this subject of Deformation of Roadbed, especially the portion referring to drainage, be retained, expanded, and further information collected by the Association.

Certainly there is no more important engineering subject than drainage. I do not know of any subject that is more nearly ignored, not only in railroad building, not only in railroad maintenance, but in all structural engineering. I believe it is a fact that really good drainage is a cure-all for about 90 per cent of all ills of railroad track. We have annual reports by a certain institution giving the causes of railroad accidents. Many of them are allocated to track, and the reason they occur comes right back to the basic fact that the primary cause is poor drainage. I think that we are prone to forget that the thing we should first consider in any engineering project, if it has a foundation at all, is drainage. This subject is not new, but we persist in almost ignoring it, providing just enough drainage to get by, and that is all. We get by in nice weather, but when it is not nice weather it is like the roof that leaks—you can not do the work in the rain.

I had occasion less than a week ago to call on my favorite barber and found he had moved. I went to the place to which he had moved and did not find him there. I went to a third place and found him. I said, "It is hard to keep track of you." He said, "I could not stay in that place, I had to get out. The place leaked." "It was a new building. Why should it leak?" "Well, the roof did not leak but the sewer stopped up." "Why did the sewer stop up?" I asked. "The plumber was there four times. It cost me $30 each time. He worked until it quit raining and got the thing fixed temporarily. The fifth time the owner's agent got a couple of laborers and started working and found there was no sewer connection. They had put the downpipe into one vertical length of six-inch sewer tile and let it go at that. The contractor saved the cost of a sewer connection. But it is all right now. The owner's agent disconnected the downpipe just under the eave and leaned it against his neighbor's roof and that building now takes the drainage from both roofs." That is just about the class of drainage existing in a good many instances on the railroads.

This subject is world-wide. Why, when Noah was 600 years old, lack of proper drainage in the Euphrates River Valley was responsible for forcing him into the shipbuilding business to protect his menagerie investment. What did we learn from that? We find Mr. Ringling with his menagerie wintering down in Sarasota, Florida, eight inches above sea level when he might have been in Phoenix, Arizona, eleven hundred feet above sea level, quite as warm and a lot dryer.

As another illustration, we have some periodical unpleasantness in the Mississippi River Valley. On this important subject we probably will hear more before the day is finished.

The point is that we all know the necessity; we know the importance of track drainage, but are not getting anywhere. I know it, because I have maintained desert track for a considerable time where there is no water and it does not cost half as much to maintain. It usually is not difficult to obtain drainage. It costs money, but the money is well spent for a permanent betterment. The trouble is that engineers are afraid to launch out and do something that somebody may adversely criticize. I am simply telling you facts. I am making a suggestion, not a criticism. I will say it is more than a suggestion. It is a plea. I plead with the Association to further this matter. I understand that the Roadway Committee has instructions to cover drainage. I understand that the Board of Direction, the Committee on Outline of Work, and all concerned have covered their work, but the individual railroad is not getting anywhere with drainage improvement. We have been at it for something over a hundred years. We have done about one-tenth of the drainage that we should do on construction and on maintenance. We are getting farther behind every year since 1824 when the first steam engine ran on rails. If you are good at mathematics you can figure that we are now something like a thousand years behind on drainage. I looked this matter up in the 1921 Manual and in that volume I found in 1004 pages three references to drainage and about one solid page of text. Certainly this Association has not overstressed drainage in its thirty years of life.

I believe that one page in a thousand, one thought in a thousand, one action in a thousand, is about the ratio of concentration that we get and of the action that we get on drainage. Drainage is right down at the bottom of things where you have to start if you are to have a good track, and everybody knows it. The subject is worse handled than the weather. Mark Twain said that everybody talks about the weather but nobody ever really does anything. We do not even talk about drainage.

It has been suggested to me that roadbed drainage has really kept pace with the improvement of railroads; that we have done as much as we went along as we economically could; that in construction days we built the ditches that we thought we should build; and that drainage improvements have been made in ratio with our other expenditures, with the result that drainage is now up-to-date and down-to-date. I will agree that we probably did what we could when the railroads were first built. I remember some of the old mud ballasted railroads. We did build ditches to run the water off and put in some culverts. Sometimes they were ten times too big and sometimes they were ten times too small, and we are at times as unscientific now when it comes to actual railroad construction as we were then in the matter of drainage.

What I especially deplore is that the roadbed in general has not been properly drained. We built a track on it. The track started to settle and we put some ballast under the ties. That settled and we put in more ballast and we got the track lifted up out of the bank. We had fine drainage, but the tracks went out of line for want of shoulder. So we went to the nearest cut, loaded some clay and distributed that along the roadbed on each side of the ballast. Thus the shoulders were raised to ballast level and the water trapped between. It is there yet. It can not get away; it does not all evaporate. Every ballast cross-section has a concave base; every railroad is being maintained on a ballast and water filled trench, making much more work for us as time goes by and heavier loads are applied to the tracks.

What are we going to do about it? We can get along in a way without many drainage improvements. It means undue expense, extra labor, a lot of material and a few accidents. So why worry? Everybody in this room will vote dry on drainage; I know it. Everybody knows what I am telling you is so. I do not have to prove it; the results show it—you all vote dry but you all act wet.

We have improved the track structure, the rail, the ties, the ballast, all the track elements, but it still rests on the original faulty mud foundation, and we all know it. Is it any wonder that our costs are high? I know I can cut in two the maintenance of a poorly drained track if allowed a reasonable time and the money to put in proper drainage. Such a statement would apply generally to a railroad, a wagon road or any other kind of road or structure. I believe every dollar that is spent on necessary improvements to drainage, which is an improvement to the roadbed under the ballast, is worth ten dollars spent on track. For the last 104 years we have been railroading from the top down, tamping the ballast, raising out slacks, keeping the track up on ballast and water. That is the only water in the railroad organization. It has been there for 104 years. If it is worth while draining off, surely we ought to do it for our own protection. This is an engineering problem, pure and simple, and it is up to you and up to me. I hope some time we can get this idea across to each other. We all know it and we say yes, but the railroads do little toward improving roadbed drainage.

Here is what I think the individual should do: I believe every engineer who starts to make an estimate should place his drainage item on the top line. Drainage should have first consideration. I think you will find if you estimate somewhere between 4 and 10 per cent for drainage in a yard project, you will not be far out. Projects vary a great deal and averages do not amount to much but we need some definite estimate in every project for drainage. Drains must be installed before the structure is built. If you do not install it before you construct your project it will be afterward unobtainable without abnormal expenditure. But there are ways and means, while we are in the business of maintenance of track, of improving imperfect drainage. There are ways and means that probably I do not know of, and there are others that you do not know of, for drainage is a broad subject of many phases.

Let's get together and formulate specifications, and inquire of geologists who do know something about the primary causes of drainage difficulties. Engineers are not specialists in geology. I know of no railroad engineer who is an expert in geology. I know very little about it, but I know a geologist who has helped me considerably in finding out how I should drain a roadbed. However, I can vastly improve track with small track drains. We are doing this on our railroad. It is astounding the improvements one can make with simple means at nominal cost toward draining a track. If I am not mistaken there are gentlemen in the room here who can tell you something about this particular work.

Anyone of you can satisfy himself of the benefits of track drainage. Take a quarter of a mile of railroad where you have pumping joints, broken rail ends, and all the other ills resulting from water under the track. You can readily drain that and compare it with an undrained section, or you can take a track crossing and drain it. If there is no drainage outlet it can be pumped. You can get a pump that will pump automatically. Even if you have only a hand pump it will take a section man only half an hour per week to pump out all the water that will collect in a sump under a railroad crossing.

After we get up to the desired standard and the drainage generally is in pretty good shape, we will not have to talk much about the bearing power of soil because the bearing power will be so great that the roadbed will be fairly permanent. No real permanency is attainable until drainage nearing perfection is accomplished.

I move that this subject be retained, and that this Association take the lead in bringing drainage before the profession, not only the railroads but before the engineering profession because we are going along in the procession, and it is pretty nearly time somebody gets in the lead and leads this procession. Unless we do it, somebody else will.

Mr. Robert H. Ford (Chicago, Rock Island & Pacific) :—I was unaware that the New York Central Lines were running so badly under water. I have been along their line recently and I thought it was first rate. I rode 300 or 400 miles on the observation car over some of the New York Central properties.

As I understand Mr. Lewis, he asks that this matter of drainage be referred back to the Committee. The A.R.E.A. has been studying this drainage question since 1907, twenty-two years, and I am quite familiar with the literature of the Association with respect to it. I do not know of any one subject that has been so thoroughly canvassed as this question of drainage. Some of the literature of this Association is classic with respect to drainage.

So far as the Association is concerned, I think they have pretty well exhausted the subject, except keeping it up to date, and that is within the scope of the Committee's work on the Manual.

I concur in the recommendations of the Committee that the subject be dropped. I do not think Mr. Lewis wishes to be construed literally, and perhaps when he sees his remarks in print he will modify a great deal of it.

So far as the Association is concerned, again I wish to say that the subject of drainage has been very exhaustively and very thoroughly investigated, and if there is any engineer, young, old or otherwise, who wishes to be informed on the question of railway drainage, I invite him to the publications of the Association. I certainly would support the Committee in their recommendations.

There is one other question, and that is the question of engineering. I yield to no man in my knowledge of the context of our American railways, and I believe that the question of drainage is well understood by our maintenance men. I believe they are doing wonderful work on the question of drainage. I believe there is much that they can do to meet the increasing axleloads of our railroads, but I should dislike to feel that we were so far behind the times, as suggested by the last speaker.

Mr. J. E. Willoughby (Atlantic Coast Line) :—I support Mr. Lewis' motion that the subject be continued.

The subject was, "Continue the study of deformation of roadbed in the light of data developed by the Special Committee on Stresses in Railroad Track." The deformation of a roadbed will be ever with us. The present report of the Committee seems to consider the deformation lies solely in the roadbed. There are other accessory matters to study by the Committee, like the subsidence of the ground on which the roadbed rests, and its correction.

My suggestion refers not merely to the subject of drainage, but I make the suggestion because deformation of roadbed will continue and, therefore, the study should be continued.

Chairman C. W. Baldridge:—Mr. Lewis' comment on the paucity of matter in the Manual on drainage is somewhat due to too literal a use of the index. If you will look in the index of our 1921 Manual, take the word "drainage" and follow it up, you will find on page 57 there is only a half page regarding drainage. However, if you will study the matter a little further you will find on pages 64, 65 and 66 there are two and one-half pages under the heading of water pockets, which has practically all to do with drainage.

On page 66 there is two-thirds of a page on yard drainage. On page 67 there is two-fifths of a page on yard drainage. On page 68 there is one-third of a page on drainage of large cuts.

In the supplement to the Manual of 1922, Bulletin 249, Roadway Committee's report, pages 1, 2 and 3, practically all have to do with drainage. The work of this Committee is not so lacking on the question of drainage.

As to the question which Mr. Willoughby raised, Dr. Talbot called your attention to the fact that before we can do very much more with this subject it is necessary to have some additional work of the other committee. For that reason we are asking that it be deferred, that it be dropped for the present. It can be taken up again when the proper time comes.

Mr. E. R. Lewis:—I am glad to be corrected. I am glad there is more about drainage, but after you get it all together, there is not very much.

I honestly believe this is one of the most important subjects in the engineering profession. It is one of the most important subjects for us to deal with because we are maintaining railroads to sell transportation, and we are making ourselves a lot of expense and trouble by not paying the proper attention, or a little more attention, to drainage. It not only affects all elements of the track but the rolling stock as well.

The President:—The motion is that the subject be reassigned, and it is seconded. Are there any comments directed at the motion?

As I understand Mr. Lewis' motion, it is that this subject be reassigned for further study.

Mr. E. R. Lewis:—As far as the drainage portion is concerned.

(The motion was put to vote and carried.)

The President:—The reassignment carries, and it will be reassigned.

Chairman C. W. Baldridge:—The next subject assigned to this Committee reads: "Continue the study and improvement of methods of preventing corrosion of fence wire."

The report of the Sub-Committee will be found in Appendix C at the top of page 216.

"The Committee reports progress, but owing to the fact that other organizations have some tests of fence wire under way but not yet sufficiently completed to permit of results being determined, no report is offered this year."

We have asked that the subject be reassigned and the Committee on Outline of Work has so ordered.

The fourth subject assigned to this Committee reads: "Continue the Study of Permanent Roadbed," and the report of the Sub-Committee will be found in Appendix D on page 216.

Mr. F. W. Hillman, Chairman of the Sub-Committee on Permanent Roadbed, will present some remarks on the report.

Mr. F. W. Hillman (Chicago & Northwestern):—The Committee conferred with railroads that it knew had some form of permanent roadbed and made a field inspection of the Pere Marquette Railway Company's installation at Beech, Michigan. One member of the Committee made a field inspection of the roadbed of the Michigan Central Railroad's tunnel at

Detroit, Michigan. The results of these investigations are given in detail in the report.

Thought was given to making a study of the train resistance on the Pere Marquette installation with the use of a dynamometer car. This was considered impractical because of the short length of the installation. However, Mr. Chipman made some tests with drifting cars and the compilation of these tests was referred to Dr. Talbot, who referred them to some of the members of the University of Illinois faculty. The details of these are given in the report.

The Committee's efforts were directed particularly to investigation of permanent roadbeds constructed without ballast. However, reports were received of some installations of concrete slabs under ballasted track, and mention is made of these in the report.

The report is submitted as information, with the suggestion that the subject be reassigned.

The President:—You have heard the Sub-Committee's report, and it will be referred to the Committee on Outline of Work.

Are there any observations or questions you desire to ask in connection with the Sub-Committee's report? If there are no questions, we will proceed to the next Appendix.

Mr. E. R. Lewis:—If I am not too far out of order, Dr. George E. Ladd is here. He is interested in the subject of drainage, and I think we would all like to hear him say a few words. He is Consulting Geologist of the Federal Highway Department, and I am sure he can tell us something interesting on that subject.

The President:—Dr. Ladd, it will be a pleasure for us to hear you. To those of you who have not heard him, I am glad to present Dr. Ladd, Consulting Geologist of the Federal Highway Department.

Dr. G. E. Ladd (Engineering Geologist, Bureau of Public Roads):—You have a full program, I am sure, and have very little time to listen to me. I am here without expectation of saying anything.

I wish to state though that next year, if I live, I should like a place on your program to give you a lantern slide talk on some of the problems I have been studying in connection with both railroads and highways.

A few years ago I addressed in Washington about 150 highway engineers on the subject of the relation of geology to engineering. They are a pretty stubborn outfit and I have had a lot of trouble with them putting over some of my ideas. I had selected 100 lantern slides that illustrated geological problems all along the lines of engineering—dams, reservoirs, stream-control, tunnels, highway failures, subsidences, and so on. It seemed necessary for me to hit them pretty hard, and I did so.

When I was through, Dean A. N. Johnson, of the Civil Engineering Department of the University of Maryland, who was there to discuss my address, was called upon. The Dean arose and in a slow, drawling way said: "With all of you gentlemen I have heard Dr. Ladd's interesting address, and I have only this to say: There *are* structures that engineers have reared that are still standing!"

I listened with very considerable interest to the brief discussion of the subject of drainage that you had before lunch, and I rather trembled. I thought something important was about to be lost.

I am a new member, an Associate member, of this organization. The principal reasons that inspired me to join it were that I might possibly render some service and that I would have an opportunity to learn a great deal. I very nearly discovered that you were through with the subject of drainage, and that I would not have an opportunity to learn anything.

I have been a geologist for a great many years. For twenty-one years I was president of technical schools and turned out engineers. In college I studied some engineering. I have had to apply it. I am very keenly interested in the subject, and very, very sympathetic with engineers, and never, of course, would say anything of them derogatory or harmful.

For ten years past I have been in the Government employ (barring the past year in which I did service work for the Armco Culvert Manufacturing Association in connection with landslides on railroads and highways). I have spent practically all of that time upon this subject of geology applied to engineering. For seven years I have pried into the subject of drainage and of desiccating areas that subside or move, and cost money—I have not by any means learned all of it yet, and I do not think that you engineers know it all.

It has happened that I have traveled a little this past year and covered nearly 70,000 miles. In addition to a large amount of work in connection with highways and other subjects, I was called upon to investigate many problems on railroads; I think altogether on 18 railroads; all the way from Southern Mexico to Canada on the Canadian Pacific and Canadian National, and from Pennsylvania to California.

I had thought that those highway engineers I mentioned were a tough bunch to deal with—ultra conservative, but since I have gone up against the railroad engineers, I have found something that is the Rock of Gibraltar compared with highway engineers. All that is another subject and I may touch on it in an article I promised to write for Mr. Howson and to others for the *Engineering News-Record*.

I have these thoughts to add: When Mr. Lewis made what seemed like radical remarks about drainage, my mind jumped back a number of years to the time when Louis Brandeis, now of the Supreme Court, made his famous announcement that the railroads were wasting millions and millions of dollars. Brandeis' name was anathema.

I remember attending at that time a meeting of a commercial club in a large city in New England. The principal subjects of discussion were the radical Roosevelt and this crazy Jew who was attacking railroads. But I am convinced, and I think everyone is now, that Brandeis was right. Tom Lawson did good when he attacked Ryan and the life insurance business; became anathema; "made" Mr. Hughes; and saved the life insurance business from exploitation and disaster. Brandeis called attention to wastes that have largely disappeared in the extraordinary efficiency that the railroads are now showing.

I believe, as Mr. Lewis seems to believe, that there is still a source of large waste in the engineering side of railroading, due to inadequate, wrongly placed, or wrong-type drainage. I have not the time or I would cite to you some very interesting cases to prove this. The costs and waste are more or less covered up in general maintenance. The construction engineer goes ahead and builds something. It comes back on the maintenance engineer, and money is plowed in and plowed in. I know of very many cases where by proper control method, by what you call drainage, and what I call desiccation, great savings could be effected. The interest on the investment required to stabilize the soft spot or the moving ground would be very small compared with the continuous, perpetual annual expenditure that goes unnecessarily into maintenance and is very largely lost sight of by everyone concerned.

I would suggest to you engineers the thought that you make a survey, that you do not just look at your general maintenance figures, but that you look at the costs at given places; assemble those figures and put it up to your executives to provide the money for permanent cures. You will see that you can save annually large sums of money; I know that; I firmly believe it; and this opinion is the result of wide observation.

I feel that if recognition of these situations does not come from you; if the facts do not go from the engineers to the executives, they will begin with the executives and come back to you. Also, the time is coming, if it has not already arrived, when the Interstate Commerce Commission with its new attitude on "prudent investment" is going to look into these very subjects (Applause).

The President:—Dr. Ladd, we are very glad you made these remarks. I wish to say that Dr. Ladd is now a member of the Association and has been placed on the Committee on Roadway. Therefore, we shall have the benefit of Dr. Ladd's advice and review during the next twelve months.

Mr. Baldridge will now proceed.

Chairman C. W. Baldridge:—The fifth subject assigned to this Committee reads: "Develop and report upon the conditions which should govern the use of culverts in construction and maintenance, and the factors which determine the most suitable type to be used." The report of the Sub-Committee is given in Appendix E, on page 233, Bulletin 310. Mr. A. E. Botts, Chairman of the Sub-Committee, will present the report.

Mr. A. E. Botts (Chesapeake & Ohio):—The conditions which should govern the use of the culverts are so diversified that your Committee could not formulate any fixed rules or standards to cover, but give you an outline of some of the important factors and offer the report as information with the recommendation that the subject be discontinued.

The President:—You have this report for information. If there are no comments or observations, it will be referred to the Committee on Outline of Work for consideration in regard to next year's work.

We now turn to Appendix F on page 237.

Chairman C. W. Baldridge:—The subject reads: "Develop and report upon drainage areas and water runoff, and the proper sizes of waterway openings required under the differing conditions in various parts of the country." The Committee's report will be found in Appendix F at the top of page 237. Inasmuch as Mr. Johnson was delayed in Washington and was unable to be here, I will say for the Committee that this Sub-Committee submitted a report of six or seven pages of printed matter some little time before we turned over the general Committee report to the Secretary. But they found the importance of this subject so great, and so much was developing on it, that they decided it best to withdraw that matter for this year, and report progress.

We have asked the Committee on Outline of Work to reassign this subject for next year, which they have done.

The next subject reads: "Prepare specifications for cast iron; for corrugated; and other types of metal culverts." The Sub-Committee's report is given in Appendix G, which will be found on page 237. Mr. W. C. Swartout, Chairman of the Sub-Committee, will present the report.

Mr. W. C. Swartout (Missouri Pacific):—Before presenting the report, I wish to call your attention to two typographical errors in the printed matter. In the table on page 239 the sheet length for 36-inch pipe should be 119 inches instead of 100 as printed. At the top of page 240, second line, the fourth word should be "cinched" instead of "clinched."

Our attention last year was called to the fact that the Association had already accepted a specification for galvanized iron.

The only specification covering the galvanizing of iron or steel which your Sub-Committee has been able to find, which has the approval of the Association, is found on page 889 of the 1921 Manual and reads:

"The coating shall consist of a continuous coating of pure zinc, zinc-iron alloy or a combination of the two, the coating to be of uniform thickness and so applied that it adheres firmly to the iron or steel. The finished product shall be smooth."

The balance of the specification, covering a page and a half, outlines the methods to be followed in testing the galvanizing of the samples.

This specification, general in its terms, was written by Committee XVIII—Electricity, and therefore more properly covers wire and other materials used in electrical construction. We found that it was neither explicit nor definite as applied to sheets used for culverts and therefore have written a new paragraph covering.

We have referred the specifications to the leading fabricators and have been advised by them that there are no provisions therein which cannot be readily met by any culvert company which does first-class work.

Specification for Cast Iron Pipe.—The specification for cast iron pipe meets a need that is self-evident. We have generally been specifying our cast iron culvert pipe by simply stating pipe shall be Class A, B or C cast iron water pipe, as may suit the ideas of the engineer writing the specification, without much study or thought being given to the conditions under which the pipe will be used or whether the conditions vary from location to location. Frequently the pipe used for culverts has been rejected water pressure pipe and without regard to the defect or defects which caused the rejection.

There may be a question in the minds of some that we have included patented devices or products in our specifications. This we have been careful to avoid. For example, take the case of the spiral corrugated cast iron pipe. Cast iron pipe cannot be patented. The process of manufacturing cast iron pipe can be patented. All the large manufacturers of Class A water pipe make their special brands of water pipe by their patented processes.

The wording of the specifications, "The pipe shall be hub and spigot style, if cast iron water pipe or cast iron culvert pipe, or a ribbed or corrugated cast iron pipe of design approved by railroad company," as we have, permits the use of the pipe desired by the engineer, insures a standard strength, but does not limit the choice.

It is our belief that the specifications as they now stand amply protect the railroads on the quality of the material, while, on the other hand, we do not believe that any manufacturer can complain.

One of our members wrote me a letter which read, in part, as follows:

"I note that in the specifications for cast iron pipe a test requirement is given but that none is required for corrugated metal culvert pipe. I assume that the table showing thickness of metal for various heights of fill is supposed to stand in lieu of the strength test on the cast iron pipe."

Three-Point Bearing vs. Field Tests.—This subject of laboratory tests and their application to corrugated metal pipe is not a new one to this Committee. It was thought of and tried during the first days of our strength investigation, and has been brought to our attention continuously since.

Our opinion on this subject was stated in the first report of the Committee on "Corrugated Metal Culverts for Railroad Purposes," and is as follows:

"Culvert specifications usually include a requirement for minimum strength as determined by what are known as the two and three point bearing tests. The manner of loading is illustrated in Fig. 1. (These methods of testing have been adopted as standard by the American Society for Testing Materials.)

"For rigid type culverts where failure is evidenced by fracture, the results seem fairly consistent. However, such a method of testing would be of little value in specifying strength for a culvert made of elastic materials. This seems obvious for the reason that in a fill deflection of a flexible culvert results in building up side restraint, thereby assisting the pipe to support its load."

Subsequent studies by ourselves and other investigators have substantiated and strengthened this opinion. It might be well to briefly sum up the considerations by which the Committee arrives at this opinion.

"Any test, to be used in practical applications, should simulate the conditions under which the article tested is to perform. The first problem then was to determine the performance of the different type culverts under actual embankment conditions and to develop laboratory tests identical with these conditions. Tests which would not do this would be patently useless. From the field test installations at Farina, we determined how each type performed under actual service conditions. The readings and measurements taken showed conclusively that the rigid type performed in a manner different from the flexible type. The rigid type carried the load because of its own inherent strength with practically a negligible deflection until fracture occurred. This fracture, of course, denotes failure of this type. The side pressure on this type was only that horizontal pressure which would naturally occur in a fill and the action of the pipe itself before fracture did not affect this horizontal pressure.

It is evident, then, that a true test of the strength of the rigid pipe can be had in a laboratory by application of pressure at the top and bottom of the pipe, and no consideration need be given to side pressure which is impossible of development by this type pipe.

On the other hand, the flexible type pipe at Farina did not carry the load because of its inherent strength alone, but deflected a considerable amount, and in so doing developed a side support greatly in excess of that which would naturally occur in an embankment. In this case it is evident that the load from the embankment is held in equilibrium by the strength of the pipe itself, plus the side support developed by deflection. This typical manner of carrying the load differs radically from that of the rigid pipe, so it is evident that a laboratory test which simulates the field performance of the rigid type will not simulate field performance of the flexible type.

It seemed desirable, then, to develop a laboratory test for the flexible type, but such a test must take into consideration a developed side support which changes with each change of load. Neither the two nor three point, nor any other laboratory test known, will simulate this condition. Attempts have been made by various investigators to develop such a test, but their efforts have not as yet met with any success.

To demonstrate that the results of the two-point bearing test are not applicable to field conditions, allow me to draw a comparison.

Professor Shank of the Ohio State University ran two-point bearing tests on corrugated metal pipe from 15 to 48 inch diameter, and has very kindly furnished me with the results. His letter reads as follows:

"As requested, I am enclosing the results of a two-point bearing test on standard corrugated metal pipe, 15, 24, 36, 42 and 48 inches in diameter.

"A brief resume of how the tests were conducted is as follows:

"The load was applied to these sections by a two-point bearing, each approximately 3 inches wide, by means of a new tile testing machine with the load applied by hand and the pressure recorded by an oil gauge reading pounds per square inch on a 5-inch circular piston.

"The pressure gauge was calibrated before and after testing in order to secure accurate readings.

"Before placing each specimen in the testing machine, the thickness of metal, depth of corrugation and width of section were accurately measured. After the specimens were measured they were placed in the testing machine and the load applied by even increments of deflection progressing by one-half per cent intervals to three per cent, and by full one per cent intervals to 15 per cent. Each test was stopped at exactly 15 per cent and allowed to recoil as the load was removed. All diameters during the test and the final diameter after the load was removed were measured by a micrometer reading to thousands of an inch. Each specimen was placed in the testing machine with the longitudinal seams at the exact half point on the side."

The average of three tests on 42-inch, 12-gage corrugated pipe showed that a deflection of 7 per cent was caused by a load of 1,450 pounds per linear foot of pipe. I have chosen this deflection because it is the same as the 42-inch, 12-gage pipes at Farina, and we can make a comparison between the loads that caused this deflection.

At Farina, the filling material weighed 112 pounds per cu. ft., the horizontal projection of the pipe is 3.5 feet, and the fill height 35 feet; the product is 13,720 pounds per linear foot. Because of deflection, this pipe experienced a relief in load of approximately 46 per cent, which would leave the actual load on the pipe 54 per cent of 13,720, or 7,608 pounds. The laboratory test told us that at 7 per cent deflection this pipe would carry only 1450 pounds, while it is actually carrying in the field five times this, or 7608 pounds. This additional strength is due to the side pressure developed through deflection of which the 2-point bearing test takes no consideration, giving a result only 20 per cent of that attained in the field.

Making a similar comparison between the 3-point bearing test and the Farina installation of the 24-inch diameter, we find that for the same deflection, the laboratory test developed 35 per cent of field test loading.

The fact that this percentage varies, as illustrated by the two examples, is the reason why no correlation can be made between the 2-point bearing test and field installations for the flexible type. The detailed results of these tests will be given in full in the Proceedings.

Until such time as a laboratory test is developed, which considers side support, it will be necessary to specify the strength of the flexible pipe based on field tests rather than laboratory tests.

Due to the uniformity of this product, such a method seems satisfactory and there is no dire need of continued checking of strength by any laboratory test.

In further substantiation of this, I have a letter from Professor Janda, formerly of the University of North Carolina, who had made extensive investigations both in the field and laboratory on all type pipes, and who made an earnest effort to correlate laboratory tests with field installations of the flexible pipe. He was unsuccessful in this correlation because of the reasons given above, and so states in the following letter. I may say that these tests were carried on at Chapel Hill, North Carolina, in collaboration with the Federal Bureau of Highways and the University of North Carolina. He writes as follows:

"As a result of my experience in connection with the culvert strength investigation carried on at the University of North Carolina, where I tried to correlate laboratory and field tests on corrugated pipe, I am able to offer the following:

"The only possible value, that I can see, of a laboratory test is to correlate it to field behavior, and this is indeed most difficult. If a simple and practical laboratory test could be devised that would produce the same elastic distortion of the pipe as was experienced in the field, it would be of great value to both the engineer and the manufacturer, for then one could tell the maximum height of fill that could be erected to produce a certain maximum deflection.

"The usual 3-point test of pipe is satisfactory for the rigid class of pipe, for they depend entirely upon the inherent strength of the material used in the construction of the pipe. Flexible pipe, on the other hand, deforms with the earth load, and, in so deforming, utilizes the passive thrust of the earth to assist the pipe to carry the vertical loads. This means that the greater the horizontal distortion (lengthening) the greater the passive earth pressure, and consequently, the greater vertical load that can be carried. This fact has been proved by the tests at Farina, Illinois, and Chapel Hill, North Carolina.

"A 3-point laboratory test on corrugated pipe will not indicate the true behavior of the pipe in the field, because by this test the pipe is not deformed the same as when deflected by an embankment load."

May I refer to the preceding reports of this Committee, covering phases of this subject, to-wit:

A detailed report on the Farina tests on the Edgewood cutoff of the Illinois Central Railroad, given in Vol. 27, pages 794 to 828.

To the very full mathematical discussion and analysis which will be found in Vol. 29, pages 527 to 542. The method to be followed in determining the strength of corrugated pipe is given here, I believe, for the first time.

The sand box test described in Vol. 27, page 794 et seq., is a laboratory test in so far as it has been found possible to develop one, and yet it has shown that it does not simulate field conditions in several respects. This is made evident by the Farina tests previously referred to.

The fact that a laboratory test has not been developed which gives a true measure of the strength of corrugated pipe under fill conditions does not, we believe, argue either for or against the use or strength of the product. Adequate acceptable laboratory tests would be most welcome, but in the meantime, performance in thousands of installations under railroads must remain the criterion by which we must judge the suitability of the product.

Finally, we believe that durability which takes into consideration gage of sheets, protective covering, and analysis of the base metal, will remain the more important basis of selection rather than strength.

As stated in our report, we are not recommending the adoption of these specifications by this convention, but are offering them as information, with the hope that the membership will carefully consider them during the coming year and favor the Committee with any suggestions, questions or criticisms which may occur to you. After this further study they will be called up for adoption at the 1930 convention.

The President:—You have heard the Committee's report. It is very interesting. We are not asking for any action, but would be pleased to receive from you any comments or observations you may have. If anyone has any remarks to make, please announce them now or please write the Committee.

Mr. Robert H. Ford:—I feel the Committee have unwittingly violated a custom in practice which has been established by this Association. They have included, and I will ask them if they will not please delete on page 237, beginning in the eighth line with the word "we," and ending the paragraph. The reason for that is this: This Association is one of research investigation. We have to be very careful with the quality and character of our work, and we have to rely very largely and to work with those people who deal with the railroads.

It is not the practice of this Association to lay ourselves open in any way to advertising, either directly or indirectly, proprietary or patented articles.

While I appreciate that we ask for and invite the assistance of all manufacturers and others, at the same time the work of this Association must be, and should be, kept neutral. I therefore will have to ask the Committee if they will not delete those words.

For the same reason, although I am not sure of my ground, but if it applies I will ask them to consider on page 242 the reference to the American Foundrymen's Association standard rectangular bar. It may be ignorance on my part, but if it applies, I will ask that they also consider that, too. If the American Foundrymen's Association's general standards are accepted and in universal use, it may be that I am in error.

The President:—The Committee wish to say in answer to Mr. Ford, they will take under consideration for advisement the requests for the deletion of certain references, with the exception that the association referred to is not a commercial organization and is a separate and distinct association.

Chairman C. W. Baldridge:—The next subject assigned to this Committee reads, "Develop Best Methods of Preventing the Formation of Water Pockets Under the Ballast when Embankments are Widened and/or Raised." The report of the Sub-Committee is found in Appendix H on page 243. Mr. E. C. Oyler, Chairman of the Sub-Committee, will present the Sub-Committee's report.

Mr. E. C. Oyler (Pennsylvania):—We believe that the subject-matter shown in Appendix H, page 243, Bulletin 310, fully covers the assignment in outlining the best methods of preventing the formation of water pockets under the ballast when embankments are widened and/or raised. It provides a standard which may be adopted wholly or in part, depending upon the many varying physical conditions which prevail.

I move that this report be accepted, included in the Manual, and the subject be discontinued.

The President:—It is moved and seconded that Appendix H, reported at the top of page 243, be adopted and published in the Manual. The Manual will be issued in August. Is there any discussion on Appendix H?

Mr. E. R. Lewis:—I have no wish to take up any more time, and I have no wish to impose upon your good nature. I am only wondering whether the Committee would not like to consider the case of these two phrases, porous material and pervious material, and what they mean. Is there not some preferable porous material and some preferable pervious material that we might mention?

Chairman C. W. Baldridge:—The pervious material referred to of course means anything that will permit the water to drain out readily, and the kind of pervious material that may be available in the different localities is so varied that it seems to me and the Committee useless to go farther than to term it pervious material. I think that will cover anything which will permit good drainage.

The President:—Are there any more remarks or observations, or discussion, on the question before the house? The question is for the adoption of the report of the Sub-Committee and inclusion in the Manual.

(The motion was put to vote and carried.)

The President:—It is so ordered.

Chairman C. W. Baldridge:—The last subject assigned the Committee is the usual one, outline of work for the ensuing year. Inasmuch as the outline of work for the ensuing year is submitted to the Committee on Outline of Work and it has been acted upon, I would ordinarily not say anything more about it except to invite you to read it for yourself. However, in view of the action taken a little while ago, I want to read to you the following subjects assigned for next year.

The second subject reads: Study and report upon methods of laying and maintenance of tile and other drains along railway tracks, or roadbed, under varying conditions.

Subject No. 6: Continue study and report upon drainage areas and water runoff and the proper sizes of waterway openings required under the differing conditions in various parts of the country.

By vote of the Association, we also now have another drainage subject assigned us which it will be the duty of the Outline of Work Committee to assign, I suppose, making three drainage subjects assigned to this Committee for next year.

I was very glad to find Dr. Ladd was a member of this Association and has been assigned to our Committee. I have known that, of course, since the "President's Message to Committees" was put out, and I wish to assure him that there is going to be no danger of his being obliged to waste his sweetness on the desert air next year. We will have drainage subjects a-plenty for him to work upon.

The President:—This concludes the report of Mr. Baldridge. If there are no questions to be asked, the Committee is excused, and the Association wishes to thank Mr. Baldridge and each of the Sub-Committees for their work, and all the discussion it has brought out. The Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON BALLAST

(For Report, see pp. 245-257)

Chairman E. I. Rogers (Peoria & Pekin Union) :—The report of the Committee on Ballast will be found on page 245 of Bulletin 310. On page 245 are the various subjects which have been assigned, and the first of these is the Revision of Manual. This will be found in Appendix A on page 246. Mr. M. I. Dunn, Jr., will present this Sub-Committee report.

Mr. M. I. Dunn, Jr. (Chesapeake & Ohio) :—I wish to state on behalf of this Sub-Committee that proof sheets of all matter to be contained in the Ballast section of the 1929 edition of the Manual were checked over by the Committee to insure inclusion in proper sequence of matter adopted since publication of the 1921 edition. Some changes in sequence were made on the proof sheets in order to present the matter more clearly and the few typographical errors noted were corrected. Proof sheets were then returned to the Association Secretary.

It is recommended that the definition of "Foul Ballast" be revised to assign contributary fouling to disintegration of the ballast itself. This definition is found on page 69, 1921 Manual.

Present form: "Foul—Ballast.—Ballast which has lost its porosity through the filling up of the voids by cinders, coal dust, dirt or other foreign matter."

Proposed form: "Foul—Ballast.—Ballast which has lost its porosity through the filling up of the voids by cinders, coal dust, distintegration of the ballast itself, dirt or other foreign matter."

It is recommended that paragraph 3 of the section relating to Proper Depth of Ballast, page 79 of the 1921 Manual, be revised as follows to render same more applicable to all climatic conditions.

Present form: "(3) These depths are required, under the conditions named, to support the track structure; to provide good initial drainage; to provide against upheaval by frost; to serve as a cushion for the track."

Proposed form: "(3) These depths are required, under the conditions named, to support the track structure; to provide good initial drainage; to reduce upheaval by frost; to serve as a cushion for the track."

I move these changes be adopted.

(The motion was put to vote and carried.)

Chairman E. I. Rogers:—The second subject is: Review and Report Revisions, if necessary, in Specifications for Washed Gravel Ballast. This will be found under Appendix B, page 247. Prof. C. B. Stanton is Chairman of this Sub-Committee.

Prof. C. B. Stanton (Carnegie Institute of Technology) :—Before taking up this report, your Sub-Committee would like to call attention to several changes that we would like to make in the printed report.

On page 248, the paragraph at the top of the page, line three, substitute the word "adopted" for "continued" and stop the sentence at this point.

Strike out the last word in line three and the first nine words in line four. Start a new sentence with the word "studies." In line five, substitute the word "further" for the words "more definite."

On page 249, paragraph 5, line twenty-six, strike out the word "quite." At the bottom of paragraph 5, add "A.S.T.M. D-72-21 (modified)."

On page 251, paragraph 9, line six, substitute the written word "five" for the numeral "5."

See page 248, Bulletin 310, Volume 30.

The revisions that your sub-committee recommended in the "Specifications for Washed Gravel Ballast" as they now appear in the publications of the Association are as follows:

New paragraph 1 is old paragraph 1 unchanged.

New paragraphs 2, 3, and 4 are old paragraphs 2, 3 and 4, expanded to include the tolerance outlined in paragraphs (6 and 9) and paragraphs (7 and 10).

New paragraph 5 changed old paragraph 5 by substituting therefore the A.S.T.M. Standard Test, D-72-21 (modified), for the Determination of Dust, Dirt, and Loam.

New paragraph 6 is the same in substance as old paragraph 8, but is reworded and the sample changed to 50 pounds.

New paragraph 7 is old paragraph 11 unchanged.

New paragraph 8 is old paragraph 12 unchanged.

New paragraph 9 is old paragraph 13 with the addition of the word "and" in the second line to clarify its meaning.

New paragraph 10 is old paragraph 14 unchanged.

Since submitting our report for printing, we have reconsidered the wording of paragraph 6 on page 250, and we feel that the following wording would be better:

"Determination of Grading. 6. The grading shall be determined by a screen analysis of a sample weighing not less than 50 pounds. The sample shall be thoroughly dried, weighed, and separated into different sizes by means of the following screens: 1½-inch, 1-inch, ½-inch, ¼-inch, and No. 10. Each size shall be weighed and the results recorded. The sieve analysis shall be calculated as percentages by weight of the total sample retained between adjacent sieves."

Your Sub-Committee moves that this report be adopted, as corrected, for inclusion in the Manual.

The President:—Are there any comments or observations?

Mr. L. J. Hughes (Chicago, Rock Island & Pacific):—I wish to call the attention of the Committee to paragraph 5 of the specifications. The original paragraph 5 specifies rejection of the gravel if the sediment deposited is more than one-half of one per cent. I presume that that same percentage is to be carried out in the new paragraph, although it does not so state. There is no percentage shown in the new paragraph.

It has occurred to me after reading both of these paragraphs that the new one proposed is a very exact laboratory method, one which necessarily must be carried out in a laboratory having all the screens as called for.

The old paragraph 5 was a test which could probably be carried out readily in the field, although it specifies that the amount of sediment should be determined by weight.

As a suggestion to the Committee, I think that they should state some place where a field test can be made which will quickly tell whether or not the gravel meets with specification without having to go to all the trouble of making the exact laboratory determinations called for in the proposed paragraph. Surely you could determine some way in which the grade of ballast could be told by observing the amount of sediment you have obtained after washing it and allowing this water to stand in a glass receptacle where the amount of sediment could be readily observed. We could have the present proposed laboratory methods but we ought to also have some quick check which could be made in the field.

The President:—Prof. Stanton, will you answer that?

Prof. C. B. Stanton:—In answer to Mr. Hughes' question, this test that is shown here is the one that is used as a field test by the Department of Highways of the U.S. Government. As to the sizes of the pans (not having read it over lately) it seems to me they are to be as near these dimensions as possible.

This is a practical field test and is now used by practically all the highway departments all over the country as a field test.

As to the tolerance, it is apparently a clear oversight that we did not include it in moving over to the new specification, and I move it be included in the motion.

Mr. Robert H. Ford (Chicago, Rock Island & Pacific):—I wish to endorse what Mr. Hughes has said. I am a little apprehensive of these specifications and the Chairman of the Sub-Committee has rather indicated that my fears are well-founded. I am not objecting at all to the fact that these may be excellent specifications for the state highway. In my belief the best ballast is none too good for a railroad. At the same time we have got to be practical about this thing, and we who maintain these railroads know that we can go over the top so far that we defeat the purpose we are after.

I am rather doubtful about this specification. I am afraid that the urge is too stringent. I think Mr. Hughes has the right idea. I should like to ask the Committee (I hope they will not misconstrue what I am saying, because I appreciate the work they have done) if they would be willing to reconsider this entire specification from this angle: The securing of first-class ballast in a practical manner and this test so arranged that it will be simple for the field man, as we have them on the railroads, to determine with reasonable accuracy whether or not he is getting a proper ballast.

I am afraid that this specification as recommended will not be used, and for that reason I make the suggestion.

Chairman E. I. Rogers:—In answer to Mr. Ford I want it distinctly understood that we are here to serve this Association. We suggested these changes in these specifications, and the question before the house is whether or not you want to adopt them. We have given you our work and if it is not satisfactory and you want it in some other form, simpler, modified and more easily workable in the field than is now mentioned, this Committee will be more than glad to serve in any manner that we can, and we therefore withdraw these specifications and the motion adopting them, and leave the matter in the hands of the Committee on Outline of Work to tell us just exactly what to do. Is that satisfactory, Mr. Ford?

Mr. Robert H. Ford:—Yes, sir.

Chairman E. I. Rogers:—The next is Appendix C on page 252. Mr. Daniel Hubbard is Chairman of this Sub-Committee and will present his report.

Mr. Daniel Hubbard (Chesapeake & Ohio):—The summary of the Comparative Merits of Ballast Materials will be found on page 252. They are placed in the order of merit in accordance with the Manual of the Association.

Your Committee has not attempted to go into the situation as it may affect individual railroads, but rather with a view of making the review applicable to the railroad situation of the North American Continent. Actual costs are now being worked up and we hope to have them available for next year's report.

It is recommended that this be received as a matter of information and study be continued for another year with special reference to actual cost in dollars and cents, which we have not been able to get to so far.

The President:—It will be so received. If there are no questions, we will proceed.

Mr. E. M. Hastings (Richmond, Fredericksburg & Potomac):—I do not desire to stretch out any discussion on this report, as it is presented for information only. However, I direct attention to a statement which is made under heading 2, Washed Gravel, where we find this: "It fouls quickly and cannot be cleaned, it being necessary to replace entirely with new ballast."

Having had long experience with washed gravel ballast, I do not agree with that statement, and although I have never cleaned any washed gravel ballast, it is my opinion that washed gravel ballast, if manufactured in accordance with the Ballast Committee specification, which I think is an excellent one, can be cleaned. It does not foul quickly and it is not always necessary to replace it with new ballast.

Mr. J. L. Campbell (Northwestern Pacific):—The Committee indicates in its report that it has not fully covered the subject of slag resulting from the smelting of precious metals and copper ore. This is one kind of ballast that the Committee ought to investigate quite thoroughly. It is found in large quantities in the western mountain areas of the United States and Canada.

We find in that country that such slag ballast is second to none. The Committee, I believe, realizes that this particular ballast is not at all fully covered in this report.

Chairman E. I. Rogers:—In answer to Mr. Campbell, I will say that we have in the past year received some correspondence with reference to that particular kind of slag from engineers in the western country. In the recommendation for future work Subject 3 was continued for the study of comparative merits of ballast materials and their effect on operation cost.

We expect to study the various kinds of slag and endeavor to give some information on the matter next year.

Mr. J. E. Willoughby (Atlantic Coast Line):—I think the Committee in putting slag as class No. 3, and below washed gravel are in error. Slag ballast is of two kinds; broken slag, which should be classified higher than gravel; and granulated slag, which should be in the cinders classification.

Chairman E. I. Rogers:—In answer to that may we point out that this Committee this year did not place these various kinds of ballast material in the order in which they are enumerated. That is the order they appear in the Manual of the Association. It will be our province in the coming year to try to see whether or not that order of merit is right or wrong. I am in favor of leaving it just as it is because that is the way it appears in other places in our Proceedings and Manual.

Mr. J. M. Farrin (Illinois Central):—The statement is made here in the first paragraph: "Length of time between cleaning of stone ballast depends largely on the character of traffic and density." I think there should be added the character of the sub-grade. Sub-grade, I think, will have more to do with cleaning than either of them.

Farther down in the same paragraph it says: "Stone ballast is dustless, which makes it particularly suitable for lines carrying much passenger traffic." As a matter of fact, stone is not dustless, especially when it is first laid. We have a lot of stone ballast that is dusty.

It also says: "It is found that ballast made from stone of good quality is the most economical and satisfactory in regard to track maintenance." It is simply a question of where you have to get this stone ballast and what other kinds of ballast are available.

A little further on you speak of pit run gravel, and say it makes a good sub-ballast. That leads up to the question I should like to bring up as to the combination of the different kinds of ballast.

It often serves our needs very well to have ballast of one kind supporting ballast right next to the tie. You get a very good track, in fact a much better track. In reading this whole report, to me it was a little bit disappointing in that it appears to be merely an expression of views of the Committee, without any supporting data. I think that a committee investigating such a subject as this has it incumbent upon them to make some sort of an investigation and have some data that will support their views.

A mere statement of fact that one kind of ballast is preferable to another, without at least some investigation as to the cost of that ballast, both capital and operating, is a mistake.

Our publications are scattered all over the world, and are considered authoritative in nearly every place in which they go. It seems that we ought to be very careful about sending out information that represents simply the opinion and views of a Committee, without any investigation and supporting data.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—The question of slag ballast was raised. There are four types of slag ballast that I have knowledge of, one being the precious metal slag. All the precious metal slags that I have known have been very hard, crisp-breaking material, which makes excellent ballast. The next is the open-hearth steel furnace slag with which many of you are familiar. That is very black material and looks like black glass, and breaks up well. It makes excellent ballast. That is, all that I have had experience with, made excellent ballast.

The blast furnace slag varies from palpably hard stone to a sponge. Blast furnace slag ordinarily is carried out from the furnace and dumped over a bank as waste material. If the bank is entirely dry, that slag will become quite hard. If there is considerable moisture under it the steam that is formed goes up through it, and makes it porous, depending upon the amount of moisture. I have seen blast furnace slag so porous it would float, and so soft that you could break it up with your fingers.

The granulated slag of which I have knowledge, such as produced at the Gary mills of the Illinois Steel Company, looks like sand, but if you pick it up in your fingers and rub it, you will find it pulverizes just as fine as any wheat flour you ever saw. That type of slag is absolutely worthless as ballast or railroad filling material. You are better off if you never touch it.

The President:—Is there any further discussion on the ballast? If not, the Committee will take the matter under consideration.

Mr. A. F. Blaess (Illinois Central):—Our experience with granulated slag from the Illinois Steel Works has been somewhat different than that of Mr. Baldridge. We have used it in quite large quantities for filling at our Markham Yards, and we have also used a considerable portion of it for ballasting new yard tracks on our Chicago Terminal. It has proved quite satisfactory.

The President:—We have two different points of view. Are there any other points of view? If not, the Committee will proceed.

Chairman E. I. Rogers:—The next subject will be found on page 254, Appendix D, Cause and Effect of Pumping Joints in Railway Track and the Excess of Maintenance Resulting Therefrom. Mr. W. A. Roderick, Chairman of this Sub-Committee, is not present today. I will say for him that this is a subject which has been under discussion by this Association and under consideration of committees for several years.

They have assigned five primary causes, as found on the left-hand side at the bottom of page 254, with five remedies for these five causes. I might say that we represent in the 35 members of the Committee a fairly good cross-section of the railroads of the United States and Canada. While an opinion formed by this Sub-Committee of this Committee may be the Committee's opinion, still it is fairly representative. It is more representative than we are ever able to get in answer to questionnaires in trying to assemble information to bring into this body on such days as this.

I would suggest or recommend that the information contained on page 254 in Appendix D be received as information and the subject discontinued.

The President:—It will be so received and referred to the Committee on Outline of Work.

Mr. G. J. Ray (Delaware, Lackawanna & Western):—I am particularly interested in the last two paragraphs of this Sub-Committee's report which state that it has been found that pumping joints are sometimes caused by hardwood ties placed at the joint where there are softwood ties, such as jack pine or tamarack, away from the joint, and that the condition can be corrected by reversing the situation, placing the softwood ties at the joint and the hardwood intermediately. I should like to have a little further explanation of that statement.

If that is a fact, the question is how far ought we to go. Possibly we could get some of these Gulf of Mexico sponges and put them under the joint and soak up the pumping joint.

Chairman E. I. Rogers:—In answer to Mr. Ray, I will say that the information contained in those two paragraphs came to this Committee from Mr. W. O. Cudworth, of the Canadian Pacific. It had been his actual experience that where he had the condition as stated, hardwood ties at the joint and softwood ties at other points throughout the rail joint, he had eliminated this churning at the joint by reversing the situation and location of the ties. That is as far as I am able to answer, in the absence of Mr. Cudworth.

Appendix E is Shrinkage of Ballast Material. This will be found on pages 225, 256 and 257, and will be handled by Mr. W. E. Colladay, Chairman of this Sub-Committee.

Mr. W. E. Colladay (Illinois Central):—The assignment to this Committee was to determine the amount of shrinkage of ballast by comparing the yardage paid for at the point of origin with the yardage of the same material tamped and compacted in track under traffic, and is not to be confused with the shrinkage which occurs between the point of origin and the point of application.

In the section of the specifications entitled "Cross-Section of Test Section," on page 256, a suggestion has been made that the words, "tamped and ready for operation" be inserted after the word "dresssed" in the second line. Also under "Ballast Information Required" insert the words "Cubic yards of ballast loose in car at quarry." This would follow the line "Weight of car of ballast at pit or quarry." Under "Applying Additional Ballast" insert the words "and measured" after the word "weighed" in the third line.

The Committee accepts these suggestions, and the specifications will be changed to incorporate them. The Committee does not feel at this time that it has sufficient data to warrant its making a report, but it is interesting to know that on a few tests which are under way the results indicate that considerable shrinkage has occurred after the ballast has been placed in track and tamped.

A section established on a stabilized roadbed twenty-five years old indicates the initial shrinkage of the stone ballast of 22.6 per cent, and in two months after installation a total shrinkage of 37.4 per cent. A test section on a ballast deck trestle, ballasted with smelter slag, indicates an initial shrinkage of 10.1 per cent and in two months of 14.1 per cent. Another test section on a ballast deck ballasted with crushed stone indicates an initial shrinkage of 14.4 per cent and in four and one-half months of 22 per cent, the shrinkage remaining at 22 per cent for the last three months.

As this subject has been continued for another year, the Committee hopes to have the results of the tests on other ballast material as well as the final results on the test sections already established. The report is submitted as information.

The President:—This concludes Mr. Rogers' report. We are very appreciative of the information and the discussions, and we thank the Committee for its work. The Committee is now excused with the thanks of the Association. (Applause.)

Mr. Robert H. Ford:—Before the Committee leaves, I should like to ask the Association to help this Committee during the coming year. There is a great deal of research work necessary, and they are having difficulty in getting information that they should obtain from the members of the Association. I would urge for the coming year that their questionnaires be replied to with greater thoroughness than they have been able to get during the past year.

DISCUSSION ON TIES

(For Report, see pp. 291-321)

Chairman W. J. Burton (Missouri Pacific):—The report will be found in Bulletin 311, page 291. For the first subject, Revision of the Manual, the Committee has no recommendation.

The second subject, that of Anti-Splitting Devices, will be presented by Mr. E. L. Crugar, Chairman of the Sub-Committee.

Mr. E. L. Crugar (Illinois Central):—The report of the Sub-Committee on Anti-Splitting Devices appears under Appendix A on page 293 of Bulletin 311. The report is offered as one of progress only and investigation is now under way, as outlined in the text. The Committee still has the ties under observation and will make a further report upon the subject.

The President:—Thank you very much. It will be received as information.

Chairman W. J. Burton:—Adherence to Specifications is the third subject. The report of the Sub-Committee will be found on page 295. The Chairman of this Sub-Committee is unable to be present.

This morning Mr. W. C. Cushing, of the Standardization Committee, mentioned the importance not only of the specifications themselves but of the close adherence to specifications. There is probably no item on the railroad of which this statement is truer than that of cross-ties. Cross-ties are different from most other items entering into railroad construction because each individual unit must be inspected. In the case of rails or cement or most other materials, representative samples will indicate the character of the whole lot, so that the acceptance of the whole lot may properly be based on certain samples. But with cross-ties it is necessary to inspect each individual tie.

About three or four years ago the Committee started the practice of inspecting cross-ties accumulated at treating plants, with the idea of determining how closely specifications were being adhered to. Year by year an improvement in the adherence has been noticed. The improvement during the last year was very marked, and today on certain railroads there is almost nothing left to be desired in this matter of adherence. The ties, to a large extent, are properly inspected.

The next report is that on the best practice for Switch Tie Renewals. The report will be found on page 296, and will be presented by Mr. W. C. Bolin, Chairman of the Sub-Committee.

Mr. W. C. Bolin (Baltimore & Ohio Chicago Terminal) :—This subject has been under consideration for several years. The practice on a number of representative railroads was reported in Bulletin 292, page 205. Last year the conclusions arrived at, with some of the reasons therefor, were reported to the convention in Bulletin 301, page 237, with the recommendation that it be received as information, and that a recommendation based on the report would be offered this year for inclusion in the Manual. There was some discussion of this report last year, and the Committee has also received some communications during the year, all of which have been given consideration.

The Committee this year recommends a revision of the Manual, that an addition be made to the sentence on page 106 of the 1921 Manual, reading as follows: "The practice of single tie renewal is recommended for both cross-ties and switch ties." I so move.

The President:—You have this before you. It has been moved and seconded that this amendment be made to the Manual.

Mr. A. F. Blaess (Illinois Central) :—The proposed addition to the sentence on page 106 of the 1921 Manual, to make it read as follows: "The practice of switch tie renewals is recommended for both cross-ties and switch ties," it seems to me should be given further consideration before adoption for inclusion in the Manual.

The Committee on Ties sent out a questionnaire to those railroads most closely in touch with the several members of the Sub-Committee, total mileage covered being approximately 180,000. Tabulation of replies is contained opposite page 206, Bulletin 292, December, 1926. It is shown that there is no uniform practice in the renewing of switch ties, and the Committee, in their report as contained in Bulletin 292, stated that renewals in complete sets and renewals by individual ties were almost equally divided as to mileage and number of railroads. In this same report the Committee stated it was the desire to give the subject further study before making recommendations.

In their report for 1928, the Committee advised that they had considered further the results of questionnaire above referred to, and on the basis of the information before them they made recommendations as printed on page 247, Bulletin 301, that switch ties should be renewed individually. They recommended this be received in 1928 as information and, if no material objections were received at the following convention, a recommendation be made for adoption and publication in the Manual. It would seem only one criticism was received, that from former Chief Engineer C. A. Morse, of the Rock Island, published on page 1287, Vol. 29, of the Proceedings. Mr. Morse's criticisms very clearly outlined the advantages of renewing switch ties out of face as compared with individual renewals.

I plead guilty to not having offered criticism prior to this time. Nevertheless, it is a matter of such great importance, in my mind, that it is worthy of the most thorough consideration and discussion before it is approved and adopted for publication in the Manual.

For a great many years it has been the practice on the Illinois Central System to renew main track switch ties out of face. When such renewals are made, all ties relieved that have additional service life are reinserted in making repairs and renewals of switch ties on inside tracks. By following this practice it is our judgment that we have been able to maintain a much better riding condition over main track turnouts without increased cost than would have been possible had the turnouts been disturbed in several different places for the purpose of making individual tie renewals. In renewing a set of switch ties out of face, it is the general practice to give the turnout a general resurfacing, obtaining a uniform bearing and surface throughout.

The statement made in the report to the effect that ties taken out when a set of switch ties is renewed out of face are not utilized if they have further service life, is not correct, at least so far as the railroad with which I am connected is concerned. In my judgment this is a matter of supervision, and by proper inspection and supervision there is no good reason I know why ties which have been removed from the main track and still have some service life cannot be used to advantage on inside and less important switches. It is a fact that in some instances ties under frogs and the head blocks need more frequent renewal than the remainder of the ties in the set, and in such case it is desirable to replace such ties without renewing the entire set. The rule covering the renewal of switch ties on the Illinois Central reads as follows:

"Switch Ties.—In making renewals of switch ties in main track (except as noted below), they should be renewed out of face and ties relieved be very carefully inspected and such of them as are good for further service be used in patching sets of switch ties in siding and yard tracks. Where the relieved ties are not serviceable in their entirety, but can be made serviceable by sawing off one or both ends, this should be done and such ties used as cross-ties in siding or yard tracks.

"In main tracks where merely the head blocks or the ties under the frog need renewing, it will be permissible to replace these with other ties without renewing the entire set.

"In renewing switch ties in siding and yard tracks, only the ties which are in need of renewal should be removed. In making such renewals, serviceable ties relieved from other sets must be used when available before using new switch ties."

The Illinois Central, so far as consistent, is endeavoring to follow recommended practices of the A.R.E.A. but in the instant case, from our experience, I do not feel we would be warranted in changing from our present practice to conform to that recommended by the Committee on Ties this year.

I would respectfully suggest the matter be given further consideration and that further investigation be made before adoption and publication in the Manual as recommended practice.

The President:—Are there any more observations on this particular question? If not, Mr. Burton wishes to make some remarks with regard to reconsideration.

Chairman W. J. Burton:—One point the Committee wishes to point out is that the preponderance of practice by mileage or by a count of roads means very little. One individual road may have a better practice than the majority of the roads. In connection with its questionnaires the Committee has paid more attention to roads which have made recent changes than to the greater number following a given practice.

The relative merits of the two practices were gone into two or three years ago. We made some estimates of the results under both processes, but in view of the fact that the Illinois Central may have some additional information the Committee will be glad to consider the subject further.

The President:—Under the circumstances, we will refer it now to the Committee on Outline of Work, with the request that it take under consideration the remarks made by Mr. Blaess.

Chairman W. J. Burton:—Report of the Sub-Committee on Substitute Ties will be found on page 297. The Chairman of this Committee is unable to be present.

The data included relative to service tests of substitute ties has been obtained from answers to questionnaires and by personal inspection by members of the Committee. Attention is called to the very interesting information respecting electrical conductivity of concrete cross-ties as affecting signal circuits. This information has been furnished by Mr. W. C. Cushing.

No new designs of substitute ties were brought to the attention of the Committee during the year. The outstanding service test now being conducted is that of the "Brown" tie on The Pennsylvania Railroad. There are approximately 25,000 of these concrete ties under test.

As usual, this report is given as information.

The next subject, the "Best Practice for Grading Marks for Ties to Indicate Acceptance," is contained in Appendix E, page 306. Mr. Bolin is Chairman of the Sub-Committee.

Mr. W. C. Bolin:—The Sub-Committee has prepared a questionnaire to be sent to the various railroads by Mr. Fritch, and to date fifty-seven replies have been received. These have been tabulated and are under consideration at the present time. The results of this questionnaire will be reported next year. For this year the Sub-Committee reports progress.

Chairman W. J. Burton:—The next subject, Methods and Rules for Ties Acceptance Inspection, is reported in Appendix F. Mr. R. L. Cook, Chairman of the Sub-Committee, is not here today. The status of this subject is practically the same as that of the previous one.

The next subject, "Traffic Unit for Use in Comparing Cross-Tie Life," is to be found under Appendix G, page 308. In connection with this subject, I should like to point out that the results are to be used in connection with subsequent reports of ties renewed per mile of maintained track, and the cost per mile of maintained track. Mr. A. F. Maischaider will present this report.

Mr. A. F. Maischaider (Cleveland, Cincinnati, Chicago & St. Louis) :—The Sub-Committee has endeavored to develop a traffic density unit using a more simple formula than was submitted last year.

The traffic density unit is adjusted traffic divided by the miles of track maintained, or the freight gross ton miles plus the passenger car miles multiplied by 144, the sum divided by the miles of maintained track.

This is shown in Bulletin 311, page 309, and it is recommended that the report on this traffic unit be adopted and the subject discontinued.

I make a motion to that effect.

Chairman W. J. Burton:—Before any remarks are made, I should like to make a little amplification of the statement by Mr. Maischaider. The unit is in reality gross ton miles in which freight gross ton miles, including locomotive, are added to passenger gross ton miles, including locomotive, and the passenger gross ton miles increased by 50 per cent to allow for the speed effect.

It is equated gross ton miles, and the Committee has chosen this formula because of the availability of the statistics. The necessary data is readily available in the reports of the Bureau of Railway Economics, both monthly and yearly. This availability was a large consideration in deciding on this unit.

The President:—You have heard the motion and second for the adoption of the unit on page 309 of this Bulletin. Is there any discussion on this question?

Mr. C. C. Cook (Baltimore & Ohio) :—I should like to have an explanation of the derivation of the formula. I fail to understand it. It seems to me that it is a very important formula if we are going to apply the table that is given in the next Appendix, and it may raise some very embarrassing questions.

Mr. A. F. Maischaider:—We equated the traffic unit to gross ton miles, including locomotive; that is, the freight gross ton miles, including locomotive. That is the largest unit that most railroads have. The passenger cars are added in there on the basis of 72 tons per car, which is a figure developed by the Mechanical Division of the A.R.A., and we equated the passenger locomotive as one-third the weight of the train. That seems to be the fair average on most roads by actual check.

Mr. C. C. Cook:—How is the figure 144 arrived at?

Mr. A. F. Maischaider:—The 144 is 72 tons to the car, adding one-third for the weight of the locomotive, multiplied by 1½ for the speed effect, which is the equivalent of 72 times 2.

Mr. C. C. Cook:—The suggestion of the Committee that the effect of use upon cross-ties is different in the case of treated and untreated ties would incline me to agree with the proposal that a percentage, say of 30, is representative in one case and 50 in another, and yet I understand from this report that it is not the intention of the Committee to consider that in their application.

Chairman W. J. Burton:—Mr. Cook, the reason for that is this: The Committee is working with statistics originating with reports to the Interstate Commerce Commission on ties renewed. Those reports show the kind of ties put in but do not show the kind of ties taken out, so it is not possible with the data we have to differentiate between treated and untreated ties, in so far as ties taken out of track are concerned.

Mr. G. J. Ray (Delaware, Lackawanna & Western):—The Committee is to be commended on trying to arrive, and actually arriving, at some sort of formula. There is, however, some doubt in my mind about the results that we are going to get by these comparisons. As an illustration, I would call your attention to the fact that the average speed of passenger trains on many of the lines west of the Mississippi River is no higher than the average speed of much of the freight service between Chicago and New York.

It has been my own observation that it is easier to maintain track under passenger service than it is under freight, speeds being equal. Certainly at like speeds locomotives that pull our freight trains will do as much damage to the ties and all other parts of the track, if not more, than passenger engines.

I rather doubt that you will get any very valuable comparison with the proposed formula. You will find that on many of the Eastern roads the fast freights are moved at an average speed of 30 to 35 miles an hour over an entire division and at times traveling at very much faster speed. I know on our own railroad that our freight trains run fifty miles an hour, that is, our fast freights.

Furthermore, I know that those same trains do more damage to our tracks than our passenger trains. Therefore, I think we are going to be led into some error by following the proposed formula.

Another matter, so far as weight is concerned. Take the weight of passenger cars assumed as 144,000 pounds. This weight of cars applies to our heavy passenger cars. As a matter of fact on a suburban railroad the cars are usually very much lighter than the figure assumed by the Committee. At the same time, the mileage for suburban passenger cars will be counted when applying the data to the formula. For example, on the Lackawanna we have a great number of suburban passenger cars most of which are lighter than the weight given. The same is true of other roads and I question whether the results obtained by the proposed formula will be worth very much.

Chairman W. J. Burton:—This 50 per cent is of necessity a judgment figure. Possibly it is a little too high and possibly it is too low. The Committee was influenced somewhat by the results shown in Table B for certain roads which have unusually large proportions of passenger traffic. For instance, the New Haven and roads of that character show results in ties renewed per maintained mile considerably above roads with freight traffic in greater proportion.

The figure, however, is a judgment figure, and if anyone can tell us how to get a better figure we will be glad to adopt it. Perhaps no adjustment is necessary. The Committee would like to have the view of the convention as to this point.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe) :—I have a good deal of sympathy with this Committee on this particular question. About 10 or 15 years ago I made the assertion in a report to the Chief Engineer, the late Mr. Felt, that the passenger traffic damaged the road more than freight traffic. He asked me to prove it. I haven't yet and I don't know of anybody who has.

Mr. J. E. Teal (Chesapeake & Ohio) :—I am wondering if the Committee has considered using a formula involving speed. In this connection one might use actual speed applied to passenger equipment as well as freight equipment instead of an arbitrary one in that case.

Chairman W. J. Burton :—The second part of Mr. Teal's suggestion is contained in the report. The report recommends using actual passenger car weights where these can be obtained. The difficulty with the first part of the suggestion is this: We are of necessity dealing with system figures. The average speed of passenger trains for a system would depend upon how you arrived at that average. It would be one thing doing it one way and another thing doing it another way. It makes the matter very complicated, so, personally, I would not favor that suggestion.

Mr. J. M. Metcalf (Missouri-Kansas-Texas) :—I am under the impression that we had previously adopted a formula for the comparison of maintenance expenses which differs somewhat from this. Am I wrong about that?

Chairman W. J. Burton :—The question was raised last year as to why we didn't use the formula developed by another Committee in 1925, but that formula required certain figures which are not available, and the formula which we have developed is very readily and easily gotten at.

Mr. J. M. Metcalf :—I thought the other formula was based on the same statistics as this. Was it not?

Mr. A. F. Maischaider :—No, the formula was based on net freight-ton miles; freight car, ton miles; passenger car, ton miles; freight locomotives, ton miles; and passenger, ton miles. There were 5 different elements to it.

Mr. J. M. Metcalf :—These are the same basic figures which we use now, only a different formula. Is that right?

Chairman W. J. Burton :—They are not readily available in that form.

Mr. G. D. Brooke (Chesapeake & Ohio) :—The discussion has brought out, I think, that the Committee is attempting to develop a traffic measure comparing the life of ties. I think it is very important in determining upon the scheme that they take into account the use of treated ties on a given railroad in comparing it with some other road; that is, the practices on the two roads. Mention was made of the New Haven. I have understood, I may not be right, that that road has not been treating its ties very long. Well, that would easily account for the heavy renewals as compared with some other road that has been using treated ties. You take our own road: If we made a comparison of a period of today with ten years ago, it would be entirely different.

I would, therefore, suggest that the Committee accept the subject for further consideration another year.

Mr. J. L. Campbell (Northwestern Pacific):—It seems to me that the criticism, well taken, would be met by stating this formula in general terms, so that each road could assign proper values to the factors used. This would apply to the factor of 144 or 1½, or any others necessary to use.

Chairman W. J. Burton:—With regard to Mr. Brooke's remarks, it seems the matter of whether the ties in the track are largely treated or untreated does not have any effect on the formula for stating the tonnage or the density of traffic, or whatever you call it.

Mr. C. C. Cook:—It does have that application, however. I had thought first the Committee was getting a refinement of the formula and of the unit which the Committee on Economics of Railway Operation had developed, but it now appears they are simply trying to use statistics that are available in the I.C.C. statistics. If that is the case, it seems that they should use the same unit that the Committee on Economics of Railway Operation had formerly used, and probably use the same application, which, I believe, was 55 per cent. I think that would be consistent and would probably approach the proper application.

The President:—If there is no further discussion, the Committee wishes to have the matter tested. It is moved and seconded that what has been presented be approved and included in the Manual. Those in favor of the insertion will say "aye"; those who are opposed to the insertion will please say "no." The noes have it and it will not be inserted.

Chairman W. J. Burton:—The next report is that found on page 309, "Report Data on Average Ties Renewed per Mile of Maintained Track." This part was prepared by a Sub-Committee with Mr. J. H. Roach, Chairman, but Mr. Roach is not present.

This report is based on returns made by railroads to the Interstate Commerce Commission on Schedule 513 of the annual reports to the Commission. It consists of two parts: Table A beginning on page 310, and Table B beginning on page 315. Table A is merely a tabulation of the returns made by individual roads.

In submitting the report it seems desirable to call attention to the possibility of error in some of the individual returns. It was necessary to make a number of changes in the Table A, as the result of correspondence with certain roads, but it was not possible to take up for correction all possible errors.

I particularly want to call attention to Table B, Column 7, "Average Cost of Wooden Cross-Tie Renewals per Mile of Maintained Track." These cost figures are exclusive of the cost of insertion, but include the first cost of the tie delivered to the railroad. They represent one year's renewals only, and it is the purpose of the Committee, as subsequent years' returns are received, to derive 5-year and 10-year averages, which will be more nearly representative.

These figures, however, give an overall picture of the relative economy effected on different railroads with different tie practices. For instance, some roads make it the practice to purchase the cheapest tie per tie, and this frequently results in high cost per maintained mile.

The cost per maintained mile, taken together with the cost per ton mile, which we will try to add, gives probably the best idea as to the overall economy effected by different roads under varying tie practices.

The last subject, "Proper Size of Holes for Preboring," is a carry-over subject to be presented by Mr. R. S. Belcher, Chairman of the Sub-Committee.

Mr. R. S. Belcher (Atchison, Topeka & Santa Fe) :—The work of the Committee on this subject covers three years. The first year canvass was made of railroads which were preboring to ascertain just what their practice was at that time.

Last year, the Committee reported in detail results of extensive laboratory tests made by Mr. Chapman. As a result of the discussion of these tests at the last convention, and the conclusions reached by the Committee, we have this year rewritten the conclusions and the recommendations to cover the points brought out in the discussion.

The recommendations which the Committee give as the result of study of the laboratory tests, is also the practice of the majority of the railroads as obtained by the questionnaire.

I move the adoption of the conclusions on page 320 and 321, and the recommendations on page 321, as recommended practice.

The President:—It has been moved and seconded that Appendix I on pages 320 and 321 be received and adopted. Is there any discussion?

Mr. J. L. Campbell:—I should like to ask if the Committee has given full consideration to practical objections to having four different sized holes in the tie for various sized spikes, and whether it would be satisfactory to use one size of hole for two or more sizes of spikes, the idea being to make the matter as simple as practicable, thereby reducing the probability of confusion in delivering ties having the right size of hole.

Chairman W. J. Burton:—The Committee, after a study, is of the opinion that the four sizes are necessary for the best results.

The President:—Are there any further comments on this motion?

Mr. G. D. Brooke:—There are only three sizes as I get it—1 and 4 have ½-inch holes, and the others vary 1/16 from that size. I move that that be made ½-inch holes for that sized spike.

The President:—Are there any further remarks? If not, the question before you now is the matter of voting on page 320 for its inclusion in the Manual. Those in favor of this motion will please say "aye"; opposed "no." The ayes have it, and the conclusion is that 320 and 321 will be included in the Manual.

The President:—If there are no further comments the Committee will be relieved, with the thanks of the Association. (Applause.)

DISCUSSION ON UNIFORM GENERAL CONTRACT FORMS

(For Report, see pp. 323-343)

Chairman J. C. Irwin (Boston & Albany):—Mr. President, the report of Committee XX—Uniform General Contract Forms will be found in Bulletin 311, beginning on page 323. The only subject which this Committee presents with recommendation for adoption and printing in the Manual this year is the Form of Cost-Plus Percentage Construction Contract. This has been under consideration for three years, and has been given a great deal of study. We thought the Committee might prepare a form which would include the alternate provision for a fixed fee, but it was found, on account of a number of paragraphs in one case that did not apply in the other, that it was absolutely essential to separate it, and we are now going to present the Form of Cost-Plus Percentage Construction Contract.

The subjects will be presented by Sub-Committee Chairmen. If you will refer to Appendix A, and will read the names of the members of that Sub-Committee, you will find that our own President Faucette is a member. He has been a member of Committee XX for a great many years, and for several years was our honored Chairman. I am very glad to say that in spite of his having served as President, he is continuing as a member of this Committee.

The report of Sub-Committee 1 will be presented by Mr. F. L. Nicholson.

Mr. F. L. Nicholson (Norfolk Southern Railroad):—You will find the report of Sub-Committee 1 printed on page 325, Bulletin 311. This Bulletin was sent out to the membership during the month of November. We assume that you have read the report, in fact, we sincerely hope that you have, and are familiar enough with the report to pass judgment. The Committee will, therefore, in the interest of saving time, simply call attention to a few changes which it desires to make in the report as printed and will then leave the contract with you for approval.

On the first line, following the words, "This contract, made this," omit the word "the." This will make the wording conform to other contracts recommended by this Committee and adopted by the Association.

On page 332, number 35, under the title of "Failure of Performance by Contractor," Section (b), fourth line from bottom after the word "work" change comma to period, beginning a new sentence with capital "I," making the sentence to read "In this case the Contractor shall be paid for the work done by him."

On page 335, third line from top, following the word "equipment," insert comma.

Chairman J. C. Irwin:—This form has already been under consideration and has been presented for discussion in previous years. I now recommend its adoption for inclusion in the Manual.

(The motion was put to a vote and carried.)

The next subject will be taken up by Sub-Committee 2. Mr. E. L. Taylor, Chairman.

Mr. E. L. Taylor (New York, New Haven & Hartford):—The Form of Agreement for the Purchase of Electrical Energy in Large Volume has not yet been developed to that point where we are justified in having it printed, but it has been submitted to Committee XVIII—Electricity, although that Committee has not yet acted on the form and we expect their collaboration during the coming year. In addition to this, we have been in communication with Britton I. Budd, Chairman of the National Electric Light Association Committee on the electrification of steam railroads, and with E. W. Lloyd, Chairman of their Sub-Committee on the form of contract. We have also submitted the form for criticism to G. T. Johnson, Chairman of the Association of Railway Electrical Engineers' Committee, appointed to consider the purpose of electrification. This subject will be continued in the outline of work for the coming year.

Chairman J. C. Irwin:—This has already been reassigned to the Committee, and, therefore, no further action is necessary.

Mr. E. L. Taylor:—In Bulletin 293, page 463, there appears the Form of Agreement for the Use of Railway Property for Public Highways. At the 1928 convention, Committee XX recommended that this be dropped from the outline of work, and objections being raised by members on the floor, the Chairman, Mr. Irwin, offered to take the subject under consideration again, and this was done.

This form is again presented for discussion, but the Committee is opposed to its adoption by the Association for the reason that such agreement is of a special character, requiring individual consideration and involving questions of title to property, so that a uniform form cannot be established. The Committee recommends that this form be eliminated from the outline of work.

Chairman J. C. Irwin:—This form has been given full consideration for several years. The Committee considers it unsuitable for standardization by this Association and therefore recommends that it be dropped from the outline of work.

(The motion was put to a vote and carried.)

Mr. E. L. Taylor:—The Committee submits as information and for discussion the Form of Agreement for Wire Line Crossings occurring in Bulletin 311 at page 336, and we recommend that this be continued on the list of subjects for the coming year; it will be the purpose of the Committee to collaborate with Committee XVIII—Electricity.

Chairman J. C. Irwin:—This subject is to be continued for the coming year, and we ask that you consider it and give the Sub-Committee the benefit of your advice.

The remaining subjects have received a great deal of attention from the Sub-Committee. It has done a large amount of work. They are still in the Outline of Work and the situation will be explained by the Chairman of Sub-Committee 3, Mr. W. G. Nusz.

Mr. W. G. Nusz (Illinois Central):—The first subject assigned was a "Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project." The Committee collected a great number of contracts and have been studying them throughout the year. It has decided to divide this into two parts: First, the organization, and second, the operation of terminals. It is not possible to present either form at the meeting this year. It has been continued in the outline for next year.

The second is the Form of Application for Industry Track. The Committee has written a great many railroads and has received thirty-two replies, fourteen of the railroads sending in forms which were used. The information is not uniform, and a form requiring information to be submitted over the signature of the applicant and approved by representative railroad officers is presented as information and for discussion.

Chairman J. C. Irwin:—This is a subject on which we particularly ask your consideration and advice. Many roads have been circularized and we have been given the benefit of the information received from them as to what they have required. We hope to have this presented for adoption next year. Therefore, I ask that you study it fully and find whether it is too long or too short and advise us as to just what should be included in a form of this character so that the Committee can make a final report next year.

The President:—I have the pleasure to be a member of this Committee and with your concurrence I shall thank them for their work and ask that they be excused with the thanks of the Association. (Applause.)

DISCUSSION ON SHOPS AND LOCOMOTIVE TERMINALS

(For Report, see pp. 345-379)

Chairman A. T. Hawk (Rock Island):—Our report is found on page 345 to page 379, inclusive, of Bulletin 311.

There were three subjects assigned to the Committee this year: (A) Locomotive Sanding Facilities; (B) Locomotive Repair Shops; (C) Methods for the Safe and Convenient Storage of Crude and Fuel Oil.

The report of the Sub-Committee on Locomotive Sanding Facilities is shown on page 346, and will be presented by Mr. L. P. Kimball, Chairman.

Mr. L. P. Kimball (Baltimore & Ohio):—The 1928 convention adopted the specifications submitted by this Committee on Locomotive Coaling Stations. Although in most cases sanding facilities of some kind are provided in connection with coaling stations, those specifications did not include a detailed treatment of that part of the subject.

While it is difficult to make definite specifications on sanding facilities, there are certain combinations of facilities and equipment that are being successfully used on different railroads, and the purpose of this report as presented is to place the information before the Association as information.

Before passing I want to call attention to a couple of corrections which should be made in the report as printed. On page 355, the cut of the steam sand drier at the top of the page was unfortunately printed so that it shows the drier inverted, and on page 357, in the paragraph describing driers, where there is mention of figures 11 and 12, this should also mention figures 13, 14 and 15.

Chairman A. T. Hawk:—The next report will be submitted by Mr. W. A. Radspinner, this subject being on Locomotive Repair Shops.

Mr. W. A. Radspinner (Chesapeake & Ohio) :—The report on Locomotive Repair Shops will be found on page 361, Bulletin 311. As this is a progress report only, I simply desire to call your attention to some of the points brought out by the Committee in its investigation.

In order to get the opinion of those now operating large shops of old or modern design, a questionnaire was prepared and sent out to representative companies in the United States and Canada, to which replies were received from twenty-five railroads, one locomotive manufacturer and one architect. This questionnaire asked, in most instances, for a preference of stated design, and brought out replies which, in some cases, were not a direct answer to the question. This variation prevents giving the replies in table form because it is thought best to include some of the comments. The information in regards to combined transverse and longitudinal shop was not developed until after questionnaire was submitted and replies received. The transverse type of shops was favored over the longitudinal type by a vote of 20 to 6.

The increase of size of the repair shops in the last 28 years is illustrated by the diagrams on pages 362, 363 and 364. The photographs on pages 365 and 366 are good examples of the preferred types.

Most of the replies agree on the material for floors, the type of power hoists and the systematic installation of water, air and electric lines, but the distribution of floor space caused considerable difference of opinion.

On pages 369 and 370, the latter subject was handled under Question 3, "What portion of the total floor space should be provided for erection bay and machinery bay in (a) Transverse type; (b) Longitudinal type?"

It was recommended by several of the railroads that the amount of space required should be determined only after careful study is made of the requirement. One of the answers particularly elaborated on this subject and recommended as good practice the following procedure:

A suggested solution of the problem is to consider the type of locomotives which are to be repaired, making ample provision for repairs to the locomotive proper, and in addition, to all of the modern accessories used, such as feed water heaters, boosters, stokers, superheaters, train control, grate shakers, power reverse gear, automatic fire doors, etc. A careful time study should be made of all the machine tool operations, then allow sufficient space in the building to take care of the required machinery. On this principle the entire size of the shop depends. For example, if it is desired to give general repairs to fifty locomotives per month, having an average of five pairs of driving wheels per locomotive, there will be 250 sets of wheels to have tires turned, 500 driving boxes to have each of several operations performed thereon, and it is necessary to provide sufficient machinery to do the work without delaying other operations.

The rate at which locomotives must be turned out of shop to produce a given monthly output is found by dividing the total working hours per month by the desired output. The rate of output applies to every major operation, therefore, sufficient machinery must be available to turn five pairs of driving wheels, bore ten driving boxes, etc., in the allowable time, otherwise the shop will not be balanced.

The principle stated in this answer is probably the best work of the Committee. It is thought that considerable study of the application of this principle should receive attention for future study, and it is recommended further that the Committee continue its work of investigation of all modern shop facilities. Recommendation is made with the idea of not suggesting a standard but bringing before the Association the best practices of modern locomotive repair shops.

Chairman A. T. Hawk:—Appendix C, Methods for the Safe and Convenient Storage of Crude and Fuel Oils, will be presented by Mr. J. M. Metcalf.

Mr. J. M. Metcalf (Missouri-Kansas-Texas):—The Committee has made some study of the comparative economy of different types of pumping plants for handling fuel oil and submits on pages 378 and 379 five conclusions outlining factors which should be taken into consideration in determining the economical plant for any particular installation.

The Committee also recommends, with a view to greater safety and fire prevention, the revision of paragraph 3 of conclusions adopted in 1925, which is printed on page 379 of Bulletin 311. This revision adds to the conclusion regarding oil unloading facilities as originally adopted. A recommendation that such facilities should be located "preferably at some distance from buildings or other tracks," and further that "when tank cars are being unloaded a sign warning against disturbing them should be posted between the first car and the switch."

I move the adoption.

The President:—The motion has been duly made and seconded that these be presented for adoption. Is there any discussion on this motion?

(The motion was put to a vote and carried.)

The President:—The ayes have it, and it is so ordered.

Mr. L. P. Kimball (Baltimore & Ohio):—In connection with the report on Locomotive Sanding Facilities, the Committee desires to recommend that the Manual, which now contains the specifications for locomotive coaling stations, be revised in so far as the paragraphs for sanding facilities are concerned to include a reference to this report.

The President:—It has been moved that the Manual include a reference to this report.

(The motion was put to a vote and carried.)

The President:—A reference will be made. The Committee has finished and they are excused with the thanks of the Association for their work presented. (Applause.)

DISCUSSION ON CLEARANCES

(For Report, see page 258)

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—The Special Committee on Clearances held a meeting in Buffalo, in September I believe, with only five members present. The discrepancies in clearances which appear in the Manual and which this Committee was organized to iron out were discussed at that meeting with the result that the matter given on page 258 of Bulletin 310 was decided upon and referred to this Association and to the Committee on Outline of Work. The Committee on Outline of Work assigned the subject just as reported, as you will find in the President's Bulletin covering next year's assignments, which provides for eight or nine different committees to collaborate on standard clearances.

The President:—If there are no further questions to ask Mr. Baldridge, the matter will rest just as he stated.

The Committee will be relieved with the thanks of the Association. (Applause.)

DISCUSSION ON COOPERATIVE RELATIONS WITH UNIVERSITIES

(For Report, see pp. 1229-1230)

Chairman Robert H. Ford (Chicago, Rock Island & Pacific):—The report of the Committee will be found on page 1229. It is a progress report and is self-explanatory. Mr. Cushing will speak briefly for the Committee.

COOPERATIVE RELATIONSHIP BETWEEN COLLEGES AND RAILWAYS

A Railway Plan

By W. C. Cushing, The Pennsylvania Railroad

Although the subject of improvement in engineering education was being given consideration before the war, especially at the University of Cincinnati, nevertheless, by reason of the outcome of the late war being so dependent upon the best use of applied science, the problem of having education and business application brought more closely into unity has been attacked with renewed energy during the ten years since the war, and as a consequence the colleges, educational societies, special foundations, business interests and individual students have submitted a great deal of discussion upon it.

A partial list of educational and business societies holding meetings from time to time upon this subject is as follows:

(1) Society for the Promotion of Engineering Education—Committee XXV.

(2) American Railway Engineering Association—Committee XXIV—Cooperative Relations with Universities.

(3) American Society of Mechanical Engineers—Railway Division—Executive Committee; Sub-Committee on Professional Service.

(4) National Industrial Conference Board—Engineering Education and American Industry.

(5) American Management Association—Committee on Relations with Colleges—Education in Labor Problems and Training in Labor Administration in Engineering Colleges.

(6) Eastern Presidents' Conference—Committee on Public Relations—Cooperative Educational Work.

(7) Pennsylvania State College—Annual Industrial Conference—The School of Engineering—Ninth Conference.

Special Foundation Reports

(8) Report of Carnegie Foundation—by W. B. Larned.

(9) The Carnegie Foundation for the Advancement of Teaching—A Study of Engineering Education—by Charles Riborg Mann—1918.

(10) Yale University Committee—Transportation—A Survey of Current Methods of Study and Instruction, and of Research and Experimentation—by Topping-Dempsey, April 2, 1926.

Addresses and Papers

(11) Letter of Samuel Rea, April 9, 1922, to Henry E. Riggs, Professor of C.E., University of Michigan.

(12) William J. Cunningham—*Railway Age,* February 26, 1927, "Training Understudies for Official Positions."

(13) Otto Kahn—*New York World,* November 14, 1924, "Success Methods."

(14) Eugene G. Grace—Engineers' Society of Western Pennsylvania, January 30, 1928, "The Making of a Business Executive."

College Plans

(15) The Antioch Plan—by Arthur E. Morgan, President—"Training for Administration and Proprietorship at a Small College."—*Engineering News Record,* January 20, 1921.

(16) Massachusetts Institute of Technology—Course I-A—Cooperative Course in Railroad Operation—Established by M.I.T. and the B.&M.R.R., February 15, 1928.

I may say that every one of these is worth reading.

These meetings are usually attended by deans of colleges, directors of personnel of the large business interests like the General Electric, Westinghouse Electric, American Telegraph and Telephone Company, and others, and by some railway engineers who have become interested in the subject, not through official representation of their companies, but because of their affiliations only with engineering societies engaged in the uplift of the profession; consequently the great part of these discussions has concerned principally improved curricula in college education and methods adopted by the directors of personnel of the business interests other than the railway business for the placement of recruits for their establishments. Inasmuch as the railway in the past has drawn so largely upon college engineer students, the college professor has desired very much to have closer interchange of views with railway officials who may speak on the subject with authority.

At a meeting in Pittsburgh, May 15, 1928, called by the Society for the Promotion of Engineering Education, Committee XXV—Relations of Colleges and Railroads, and attended by representatives of the American Railway Engineering Association, Committee XXIV—Relations of Colleges and Railroads, American Society of Mechanical Engineers, Railway Division, Executive Committee, Sub-Committee on Professional Service, the following recommendations were unanimously passed:

(1) The establishment of a committee or bureau representing the railroads, with authority to act as a channel of communication between the colleges and the railroads and to interpret the needs of the railroads to the colleges.

(2) That the railroads be asked to name officials who would represent them at a conference to be held in New York City early in December, 1928, at which conference definite suggestions and recommendations could be formulated that would meet with general approval and favorable action.

Mr. G. D. Brooke, General Manager, Chesapeake & Ohio Railway, was the representative of Committee XXIV, A.R.E.A., at that meeting and wrote a clear and complete report of the proceedings.

The resolutions of the meeting indicated the belief that the railway men were not displaying sufficient interest in helping to work out practical results toward improvement in close relationship and mutual understanding between colleges and railroads.

Resolution No. 2 of the Pittsburgh meeting was carried out by Dr. S. W. Dudley, Chairman, Yale University, who wrote to the executive officers of many railroads a brief statement of the work being done, and closing with the request that official representatives be named for a meeting at the Engineers Club, New York City, December 4, 1928.

The attendants at the meeting were the following:

Baltimore & Ohio: C. C. Cook, Maintenance Engineer.
New York, New Haven & Hartford Railroad: H. P. Hass, Assistant to Mechanical Manager.
Lehigh Valley Railroad: G. A. Phillips, Engineer Maintenance of Way.
Erie Railroad Company: R. A. Woodruff, Assistant Vice-President.
New York Central Lines: G. A. Metzman, Manager, Freight Transportation.
Chesapeake & Ohio: G. D. Brooke, General Manager.
Pennsylvania Railroad: W. C. Cushing, Engineer of Standards, and William Elmer, Special Engineer.
Delaware & Hudson: W. W. Bates, Assistant to General Manager for Personnel.

The associations represented were:

American Railway Engineering Association, Committee XXIV—Relations of Colleges and Railroads: G. D. Brooke, Chesapeake & Ohio, and W. C. Cushing, Pennsylvania Railroad.

Committee on Public Relations, Eastern Presidents' Conference: J. M. Fitzgerald, Assistant to Chairman.

American Society of Mechanical Engineers, Railway Division, Executive Committee: William Elmer, Pennsylvania Railroad; A. F. Steubing, Bradford Corporation.

Sub-Committee on Professional Service (Railway Division): Marion B. Richardson, Chairman; Prof. A. J. Wood, Pennsylvania State College.

Society for the Promotion of Engineering Education, Committee XXV—Relations of Colleges and Railroads: Dean A. A. Potter, Purdue University; S. W. Dudley, Chairman, Yale University; H. P. Hammond, Associate Director, S.P.E.E.

By Invitation: Roy V. Wright, Editor, *Railway Age;* A. I. Lipetz, Consulting Engineer, American Locomotive Co., and P. M. Shoemaker, Graduate Student in Transportation, Yale University.

The discussion consisted largely of a recitation by the railway men telling:

(A) How they were obtaining recruits for their service.

(B) How they were ascertaining the intellectual preference and capacity of recruits for certain kinds of work.

(C) How they were instructing them in knowledge of the respective fields in which they were placed.

The final result of the meeting was the appointment by the Chairman of a committee to investigate and formulate a plan of action and present definite recommendations which this body at a later meeting could adopt for presentation to the railroads, in connection with this subject, which would be uniform for the railways.

The members of the committee are:

G. D. Brooke, General Manager, Chesapeake & Ohio Railway.
G. A. Phillips, Engineer Maintenance of Way, Lehigh Valley Railroad.
William Elmer, Special Engineer, The Pennsylvania Railroad.
C. C. Cook, Maintenance Engineer, Baltimore & Ohio Railroad.
G. A. Metzman, Transportation Assistant, New York Central Railroad.
J. M. Fitzgerald, Chairman (Eastern Presidents' Conference Committee on Public Relations; Assistant to Chairman).
H. P. Hass, Assistant to Mechanical Manager, New York, New Haven & Hartford Railroad.
W. W. Bates, Assistant to General Manager for Personnel, Delaware & Hudson.
R. A. Woodruff, Assistant Vice-President, Erie Railroad.

It has seemed to me for some time that the numerous committees working independently on this general subject, Cooperative Relationship Between Colleges and Railways, had not as yet succeeded in reaching any definite plan which will be practical and useful to the separate parties, but that perhaps as a result of the many conferences and writings, we might now attempt to review the accomplishments of the many admirable presentations and thoughts given from time to time.

All of those co-ordinating associations already mentioned have done much to enlarge the scope of knowledge relating to the subject.

A keynote quotation already made by Secretary Fritch in his very admirable report for the past year states the formula embodying the essential success-factors for the conduct of an enterprise, which he attributes to Sir Henry W. Thornton, as follows:

"Nothing so makes for results as organization, the avoidance of confusion. To do a thing, clear the mind, make a clean-cut picture of the thing to be done; build a formula that will fit the undertaking; organize your effort; shut out everything else and turn on the steam. Accomplishment is certain."

* * * * * *

I believe, however, that it is now time to endeavor to state the problem waiting to be solved by each of the two parties in the conference, the educators as the imparters of fundamental knowledge and the railway men as the users of the recipients of that training.

It is believed by some of us railway men that there can be considerable improvement in the method of conveying technical knowledge for use in the sciences applied to the arts, so as to equip the student with the fundamental principles which he will be enabled to use with confidence and ultimately become an accomplished engineer, or a skilled technician in the other lines of activity required of the college-trained man in the several departments of a transportation system.

Indeed, the occasion for change, provided it brings improvement with it, has been recognized by the college management, and various new methods from new ideas adopted. I have said something already on this subject in a brief note in the Past-Presidents' Bulletin, No. 309, September, 1928.

I do not wish to see the university becoming a trade school, but hope that it will maintain its distinction as the announcer of scientific facts co-ordinated into fundamental laws for imparting principles, followed by the technical knowledge of their application to the arts, and so equip the coming engineer, or student of other forms of business enterprise, with the groundwork which enables him from that point—the entrance into industrial life—to start his own intellectual engine in operation and bring forth the new ideas necessary to enable him to solve the problems given him and so become a useful man.

The Study of Man

The common single starting point of co-ordinate interest between the college and the railroad is therefore an observational study of the new applicant for knowledge, so well expressed by Mr. Brisbane in a very recent note as follows:

> "Know then thyself, presume not God to scan;
> The proper study of mankind is man."

"Pope wrote that, as you well remember, and Yale believes it, and will establish a special department for the study of mankind and human relations. Mr. Rockefeller has contributed $4,500,000 for the purpose in addition to some $3,000,000 previously given.

"How would you go about studying mankind, so interesting and infinitely various? Shakespeare knew him well, if you will excuse another trite quotation.

"'But man, proud man,
    Drest in a little brief authority,
Most ignorant of what he's most assured,
    His glassy essence, like an angry ape,
Plays such fantastic tricks before high heaven
    As make the angels weep.'

"Some men think only of dollars and do not know what to do when they get them. Others working on scientific questions often miss the beauty of this earthly residence.

"Huxley said 'the difference between a highly developed white man and an African bushman is greater than the difference between that African and a blade of grass.'

"How can you arrive at conclusions by studying such a creature as man?"

First

The Student

In addition to the duty of the University to have the best scholars for presentation of the knowledge of the subject being taught, the college professor is deeply concerned in:

(A) Placement of the student in a particular school under the most suitable curricula;

(B) The selection of the proper subjects in the curricula, and

(C) His placement to his best advantage after graduation in the line of work for which he is best adapted.

The large capacity difference between interviewers for student placement has led to so much dissatisfaction, that various plans for the determination of scholastic aptitude, ability in certain lines of work, and natural appeal for a particular line of study have led to the adoption of many intelligence tests for grading student applicants; and the success of these tests, being of equal importance in industry, has already led the large business interests previously mentioned to apply them to their own use. Merely to mention two or three, they are:

(a) Strong Interest Tests.
(b) Zyve Test for Scientific Aptitude.
(c) Iowa Placement Tests.

I will leave that part of this note with this brief statement, much information concerning which will be found in the reports already mentioned, in order to take up that part which has not been as yet dealt with to a satisfactory degree.

Second

The Business Candidate

Placement by an officer from results of an interview and appearance of candidate only has been proved to be unfair to both candidate and employer in many instances. This has been strikingly shown by Dr. B. V. Moore of Pennsylvania State College. On the other hand, E. B. Roberts, Westinghouse Electric & Manufacturing Company, stresses the recognition of the individualism of the student, and believes that "Scholarship is the best objective measure we have of the likelihood of satisfactory performance on the part of the engineering graduate." He is convinced "that a young man who has tackled the tasks which have come his way in college and done them well, as they were laid before him, will show the same attitude toward the tasks which come his way in industry."

In addition to the identical interests with the colleges and industry in the development of uniform and effective methods of placement for the particular position under consideration, the main task of the railway is to fix upon an organized plan which will give satisfactory results in the engagement of new men for the different classes of railway work, and there are two separate methods for this accomplishment:

(1) Selection by each officer in charge of a division or sub-division of employment.

(2) A general personnel department like a Civil Service Commission, reviewing the qualifications of applicants for placement in any one of the divisions or sub-divisions.

It is believed that our Company has adopted the first plan for this purpose and does not consider the second plan as suitable for railway employment, although it is, probably to a certain extent, the plan of some of the large industrial establishments.

There might, however, be a certain amount of use for both plans by each separate department of the railway company laying down a definite plan of action, which is to a considerable extent done at the present time by the Motive Power Department. In carrying this out, just to mention the subject briefly, it would be necessary to make a study of the requirements for the employment of college men in order to ascertain the annual number which can be suitably absorbed into the organization and be sure not to obtain too large a number.

A young man who has devoted a certain number of years for a special education development is ambitious and his main thought when considering employment is his future outcome. He will be much concerned in avoiding an overcrowded condition of that employment which would prevent the possibility of his attainment of his main desire. Lack of opportunity for advancement in employment is the principal reason for causing discontent. An effective plan, therefore, for dealing with this subject is very desirable in every department which has the employment of college men for various classes of work.

For determining these annual requirements, officers most interested may be delegated to call upon the various sources of employment in order to obtain the candidate desired.

These are a mere outline of the points being dealt with in the conferences referred to above.

* * * * * *

Right methods for judging fitness of a candidate are just as necessary in the case of non-technical men as in the case of the college-trained men, and so the problem for railway companies will be something as follows:

First. An effort to outline a method of judging probable capability of a candidate which will strengthen and help to equalize the varied decisions resulting from the personal interview and judgment by appearance. This may lead to:

(a) The personal interview for learning the ambitions and previous training of the candidate from himself.

(b) If college-trained, the possession of his record of scholastic ability.

(c) And possibly, in some cases, the moderate and judicious use of one or more of the "placement tests." If these were made at his college, it might be unnecessary to repeat them.

Second. (a) The Company has the right to know as much of the character, present aptitude from scholastic attainment in a chosen direction, and expectation of possible future progressive development of the candidate as he can obtain in advance.

(b) The candidate for employment has the right to know with reasonable accuracy the conditions in detail of present engagement, and the prospect for continued future advancement as the result of his successfully applied energy and loyal performance.

Trials of plans for training recruits for the purpose of developing their knowledge in the way in which it will be most useful, mutually, to the business in hand have been made and are now being made by railways, but in some cases they have not been successful for various reasons which were expressed at the meeting in New York, December 4, 1928.

Mr. Brooke can tell you in an interesting way that the Chesapeake & Ohio Railway has been progressive in introducing methods for apprenticeship instruction, and has already included several departments as well as the mechanical, viz., in the case of signal and bridge work, and it is expected to include all departments.

* * * * * *

"Some Bright Men Were School Failures"

By Dr. Arthur Dean, Doctor of Science of the Parents' Council

(New York American, November 28, 1928)

"I want to warn any boy that is not doing well in school that in all fairness to him and to this column, he ought not feel that this talk for today endorses his failure and gives him an additional reason for sitting on the fence and watching the world go by.

"It does not. When Governor Smith's sons questioned the value of education and implied that he had gone a long way without much schooling, he replied: 'But I want to tell you that it is a dangerous game to play. And just because I happened to get somewhere without much school education is no reason at all for you fellows to think you can do it. Maybe I was just lucky. The more a fellow has in his head to start with in these days the better off he is when he gets to running,' "Here's Charles Darwin, considered by all his teachers not only a very ordinary boy but really below the I. Q. of his classmates.

"And Napoleon Bonaparte, who graduated from the military academy ranking only forty-second in his class. (By the way, what became of the forty-one ahead of him?)

"Patrick Henry who preferred liberty to school when a boy and death to lack of liberty when a man, was a complete fizzle at school.

"Professor Curie, who with his wife was co-discoverer of radium, was so stupid in school that his parents removed him and put him under a private tutor.

"Robert Fulton's mind was so filled with things outside of school that his teacher called him a dullard. Perhaps he was thinking about a steamboat. Who knows?

"Oliver Goldsmith's teacher remarked: 'You are the dullest boy I ever saw.' And who remembers his teacher?

"The next time you read one of James Russell Lowell's poems, you might recall he was suspended from college because he neglected his studies.

"Pasteur spent his time drawing cartoons of his classmates and apparently had only an average I. Q.

"There was a great botanist named Linnaeus. When he was a boy his teacher remarked: 'You are fit only to be a cobbler.'

"Now these cases, folks, are too numerous and important to be ignored. The fundamental fact is that the abilities of some pupils are widely misjudged in school. Their abilities are either unperceived or misunderstood because of a course to which they are poorly adapted, to a stereotyped curricula or to the general lack of sufficient broad means for estimating their ability.

"Some of our famous failures in school were non-conformers in the classroom and remained non-conformists in life. Other boys failed in school because the school failed to recognize that there are many other kinds of intelligence than those now being measured by the tests of that name.

"What answers should the worshipers of a rating system which judges pupil's capacity only by his I. Q. give to this little story?

"A New York boy escaped from an institution for mental defectives and before the authorities had captured him had obtained and was holding a job paying him thirty-seven dollars a week as foreman in the blacksmith shop."

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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At the Annual Meeting—Thursday, December 27, 1928, to Wednesday, January 2, 1929—which I attended as a delegate from The Pennsylvania Railroad, I wrote down some brief notes which have an interesting connection with this general subject. I submit them as part of this discussion:

Engineering Education

W. E. Wickenden, Director of Investigation, Society for the Promotion of Engineering Education, spoke interestingly and informatively upon the investigation he made during the past summer concerning engineering education in England, France and Germany, and outlined in each case the marked differences between each of them and the United States in handling the problem.

Polytechnic education began in France and was taken up by the establishment of technical schools by the government in various places for the purpose of training up men in government employment, where scientific knowledge as applied to technology would be of advantage in dealing with large improvements. The influence and importance of these schools grew until they attained the grade of the universities and became a recognized part of them.

In England, on the contrary, the movement for a high technical education began in the laboring class and was dealt with in the beginning as it is for the main part today by the local schools for that purpose, and these are largely night schools. Only a small part of this education is taken care of by the large schools of technology. A part of this education also is given by the student and apprentice system by being attached to the staff of practicing engineers.

The highest degree and standard of technical education has been reached in Germany, where the slogan has become "Technological Science Is Germany's Economic Destiny." Large technical colleges have grown up largely by government assistance around a noted doctor of engineering in special research work, connected with various groups of industry, and have been placed upon absolute equality with the university trained men.

In the United States on the contrary, while technological training has reached a high degree of standard, it has not been placed on the same elevation as the Arts Courses in some of the large Universities, notably Harvard and Yale. At State Universities, however, it is not altogether so; they are more nearly equally treated.

Finding and Encouragement of Competent Men

F. B. Jewett, Vice-President of the Bell Telephone Company and Director of Research Laboratories, spoke of the great responsibility of one man endeavoring to form a correct judgment of the capability of another man and the importance of ample recognition for encouragement.

How Should the Research Worker Be Compensated

Willis R. Whitney, Director, Research Laboratories, General Electric Company, spoke upon this in a general but very clever way, beginning by saying "I do not know anything about this subject and neither do you."

There are three forms of research:

(1) That of industry.
(2) That of the government.
(3) That in the colleges.

The desire for forward movement is the energizing force behind all. "Standing Still Is Going Backward."

It would take a thousand years to find out what some men are worth, but after all appreciation is nothing but horse sense. It is the case of every competent man that he will work harder and more if he be given the necessary floor space and assistance.

He was conversing with a friend, a man prominent in financing large industrial enterprises, about one of their men, and said, 'he is worth $1,000,000 a year to the General Electric Company.' 'Why don't you pay it then?' said the other. 'It is not customary,' was the rejoinder.

Economic Aspects of Research

L. V. Redman, Director of Research, General Bakelite Corp., analyzed the results of three different plans of investment by means of diagrams:

(1) Investment in gilt edge bonds at simple interest.
(2) Investment in a change in manufacture at compound interest.
(3) Investment in research work for bringing about reduction in cost of manufacture of a certain product, this being the most productive, if the discovery comes up to anticipation.

Philosophy of Science

Dr. Michael I. Pupin, Director of Electro-Mechanical Engineering, Columbia University, was the guest speaker at luncheon in the Fraternity Club building.

This is what he calls the philosophy of three M's.

(1) The Motive, which is unselfishness.
(2) The Mental Attitude, which is research governed by truth only.
(3) The Method of Work, which is attacking the problem by the use of the best inventive genius, such as that of Newton, Faraday and a mighty army of others.

He quoted Professor Roland's saying that "Real Democracy is an Aristocracy Consisting of the Men of Brains and Training."

Almost coincidentally with these remarks, Dr. Pupin gave this statement following to the public through the *New York Times* of January 13th, 1929:

PROGRESS IN ELECTRO-MECHANIC PHYSICS

Dr. Pupin, Professor of Electro-Mechanics at Columbia, announces three groups of discoveries during the past year of the very highest importance in the quest of the ultimate nature of electricity, light and matter.

First Group

Confirmation of the previously announced theory of the French physicist de Broglie, that electrons or electric particles may behave like waves, the 'equivalent wave-length' of an electron depending upon its velocity. The results mean that just as light rays, ordinarily considered to be waves, have been found to act like corpuscles, so electrons, ordinarily considered to be corpuscles, are now found to be like waves.

Confirmations were by C. J. Davison and L. H. Germer of the Bell Telephone Laboratories, through experiments on the scattering of narrow beams of electrons by single crystals of nickel, by G. P. Thomson of Aberdeen University, Scotland, by passing electrons through crystals and observing the diffraction patterns formed; and by E. Rupp, of Gottingen, Germany, who diffracted electrons with a ruled grating.

Second Group

In 1927 Professor Arthur H. Compton, of the University of Chicago, was awarded a Nobel Prize in physics for his discovery that a quantum of X-rays may interact with a free electron, according to the ordinary laws of mechanics, giving the electron a part of its energy and momentum, which energy and momentum is lost by the X-ray.

Professor C. V. Raman, of the University of Calcutta, India, working with visible light scattered from liquids and solids, and Bergen Davis and Dana P. Mitchell, of Columbia University, working with X-rays scattered by carbon, aluminum and beryllium, extended this result to the case of electrons, which are not free but are held by force of attraction inside the atom. A striking difference is that here the X-ray quantum may either gain or lose energy, depending upon the condition of the electron with which it reacts. The amounts of energy gained or lost correspond to the energy differences between two states of the scattering electron.

Third Group

By experiments in the high Andes, Professor R. A. Milliken, of the California Institute of Technology, measured the approximate wave lengths and hence the energy of the cosmic ray quanta, the highly penetrating radiations from the heavens. One of these quanta was of such magnitude as to suggest that it may be produced in interstellar space by the union of four hydrogen atoms to form an atom of helium, but since the mass of an atom of helium is less than that of four hydrogen atoms, the excess mass must be emitted as an energy quantum, according to the mass-energy equation of Einstein.

(NOTE.—There appears to be a relation between these discoveries and the announced forthcoming seven-page paper of Einstein, mathematically demonstrating the relationship between electrons and mechanics. W.C.C.)

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The President:—Gentlemen, this concludes the report of the Committee on Cooperative Relations. This Committee has presented to you a very excellent piece of work and observations. This Committee is composed, as you know, of personnel selected from our Association. While I have the honor of being on that Committee, still I am in a minor capacity.

We will excuse them in just a minute with the many thanks of the Association, and with the full appreciation of the duties and standards set out for the accomplishment through that source. We have, absolutely, utmost confidence in what they will do, and on the standard of personnel they carry in the names of their Committee, we feel sure of what will be accomplished. (Applause.)

DISCUSSION ON RULES AND ORGANIZATION

(For Report, see pp. 381-389)

Chairman W. C. Barrett (Lehigh Valley):—The report is printed in Bulletin 311, and you will find it beginning on page 381. Four subjects were given the Committee for study and report.

On the first, Revision of the Manual, we have no special report. Mention will be made of that a little later.

Subject 2, "Continue the study and report on rules for the guidance of employees of the Maintenance of Way Department, with special reference to: (a) Rules for employees who operate and maintain motor cars." Mr. Backus will present that report, which is found in Appendix A.

Mr. M. M. Backus (Illinois Central):—Your Sub-Committee has completed a careful study of material appearing in the 1921 Manual and its Supplements, with a view of including in the new Manual to be published in the near future all of the material reported by Committee XII and approved by the Association. Care has been taken to secure proper sequence and avoid repetition.

The Sub-Committee desires to present for inclusion under Rules for Employees Who Operate and Maintain Motor Cars, Rule 297, appearing on page 383, Bulletin 311. This Rule was prepared by Committee XXII—Economics of Railway Labor.

Your Sub-Committee is presenting for inclusion in the Manual under the subhead, Care of Right-of-Way, Rule 651 and Rule 661; and under Care of Roadway, Rule 692.

These three rules are taken from material prepared by Committee I—Roadway, and were submitted by that Committee last year as information.

I move that these four rules be approved for printing in the Manual.

The President:—You have heard the motion. Is there any comment?

(The motion was carried.)

Chairman W. C. Barrett:—Under subhead (2-b) Rules for Employees of the Buildings Department, the Committee's report will be found in Appendix B. Mr. B. R. Kulp, Chairman of the Sub-Committee that prepared those rules, will now present the Committee's report.

Mr. B. R. Kulp (Chicago & Northwestern):—Your Sub-Committee on rules for the Guidance of Maintenance of Way Employees pertaining to buildings have been worked up and appear on page 383, Rule 1661 to Rule 1681, inclusive.

These rules were submitted to the convention at the last session and referred back to the Rules Committee and the Buildings Committee with the view of differentiating a little closer between rule and specification. They were then worked up in line with the suggestion of Board of Direction on difference between rule and specification as suggested by Miss Catherine A. Fisher, Director of Household Engineering, in which she defines a Rule as "A law ordinarily authoritatively governing conduct or action"; a

Specification as "An accurate and detailed description of material for the method of employing material."

After working up the rules in collaboration with the Buildings Committee, they were submitted to Mr. Ford and Mr. Campbell for their suggestions, and with one or two changes, Mr. Campbell agreed. Mr. Ford sent them back and suggested that we adhere to the above differentiation as close as possible, which we had already complied with in making these rules.

They were amended, and published in Bulletin 311 as a final conclusion. Therefore, I recommend that they be adopted for publication in the Manual.

Mr. Robert H. Ford (Chicago, Rock Island & Pacific):—Not being able to follow the speaker as to the suggestions or changes made by the Committee, I should like to inquire in what way has the Committee changed the definition of "Rule" and "Specification," as defined by the Board and sent to the Committee for incorporation in their report. I did not understand that it was the province of the Committee to do more than include them in the report.

I want to say for the benefit of the Committee and the Association generally, this question of "Rule" and "Specification," which has been before the Association for a number of years, was adopted after the most painstaking study.

With all due regard to the Committee, I do not consider there was any need of any changes. I should like to inquire whether they have, or have not, made any changes in them.

Mr. B. R. Kulp:—In answering your question, Mr. Ford, in these rules, pertaining to buildings, we made one or two slight changes. If I understand you right, you refer to the differentiation between rules and specifications. If you do, we made no changes. I will let Mr. Barrett, the Chairman, answer that more fully.

Chairman W. C. Barrett:—I think I can answer Mr. Ford's question. He wrote to me directly with reference to a new definition of a "Rule" and a new definition of a "Specification," which the Board had adopted to take the place of those previously adopted. The previous rules that this Committee had prepared with reference to buildings were prepared with the old definitions in mind, so when we got these new definitions which the Committee thoroughly understood from Mr. Ford's letter had been approved by the Board of Direction and substituted for the others, we immediately revised the rules so far as we were able in accordance with the new definitions. We made no change whatever in the definitions.

When I received Mr. Ford's letter I immediately wrote to Mr. Fritch, but, as I understood at the time, the Committee's report was already in the hands of the printer. It was not possible to put those new definitions in the Bulletin, and Mr. Ford suggested that if that were not possible the Committee embody them in the report which would be made from the floor of the convention.

For that reason, we are quoting them today so that they will appear in the Proceedings just exactly as they were approved by the Board of

Direction. I believe that ought to be clear. We made no change in the defintions that the Board gave us; the only changes we made were in the rules in order, if possible, to make them comply with the definitions.

Mr. Robert H. Ford:—The explanation is satisfactory.

The President:—It has been moved and seconded that Appendix B on page 383 be approved for inclusion in the Manual. Is there any discussion on this motion?

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—On page 384, Rule 1674, in regard to showing the time of erecting and painting being "covered for weather protection." According to this information, I do not believe it is advisable to provide in the rule that it should be covered. That may be taken literally and covered so it can not be seen. I would suggest to the Committee that the words, "covered for weather protection," be changed to read: "where sheltered from the weather."

The President:—The Committee accepts the suggestion from Mr. Baldridge. Is there any further question on Appendix B?

(The motion was put to a vote and carried.)

Chairman W. C. Barrett:—Under Subject 2-c, Rules for Maintenance of Bridges, the Committee only reports progress. The Committee is not ready to submit a report for information. They expect to have something definite to submit at the next convention.

Under Subject 2-d, Rules for Maintenance of Other Terminal Structures, the Committee's report will be found in Appendix C. Mr. A. B. Griggs, Chairman of this Sub-Committee, will make the report.

Mr. A. B. Griggs (Atchison, Topeka & Santa Fe):—The report of this Committee appears under Appendix C on page 385 of Bulletin 311, under the caption, Rules for Maintenance of Other Terminal Structures. The report is for information only.

I will not read the subject-matter except by topics, which are as follows: Oil Houses, Coaling Stations, Ash Pits, Turntables and Track Scales. Under Oil Houses, one rule is proposed, under Coaling Stations two rules proposed, under Ash Pits, four rules proposed, under Turntables, five rules proposed, and under Track Scales, thirteen rules proposed.

Chairman W. C. Barrett:—Under Subject 3, "Continue the study of titles below rank of Division Engineer, which are employed to designate positions of corresponding rank in maintenance of way service, and make recommendations that will promote uniformity in nomenclature," the Committee's report will be found in Appendix D, which will be presented by Mr. Brooke, a member of that Sub-Committee. Mr. Harsh, the Chairman, is absent.

Mr. Richard Brooke (Chesapeake & Ohio):—A questionnaire was sent to sixty-six railways, and a summary of the replies is shown under Appendix D, page 387, Bulletin 311. These titles have been in general use by the Association for a number of years.

I shall read each of the titles and pause a moment to give an opportunity for comments.

"1. Division Engineer is title of chief maintenance officer on Division.

"2. Supervisor of Bridges and Buildings is the title assigned to the supervisory officer responsible for maintenance of bridges, buildings and structures.

"3. Supervisor of Water Service is the title assigned to the supervisory officer responsible for maintenance of water service.

"4. Supervisor of Signals is the title assigned to the supervisory officer responsible for maintenance of signals.

"5. Supervisor of Telegraph and Telephone is the title assigned to the supervisory officer responsible for maintenance of telegraph and telephones.

"6. Supervisor of Track is the title assigned to the supervisory officer responsible for maintenance of track.

"7. Supervisor of Work Equipment is the title assigned to the supervisory officer responsible for work equipment."

I move that these titles be adopted for publication in the Manual.

The President:—Please refer to page 387 in which you have before you seven items. It has been moved and seconded that they be adopted. Is there any discussion on this question?

(The motion was put to a vote and carried.)

Chairman W. C. Barrett:—Subject No. 4 is "Prepare rules for fire prevention as applying to railway property." The report of this Sub-Committee will be found in Appendix E, and Mr. W. C. Mack, Chairman of the Sub-Committee, will present the report.

Mr. W. C. Mack (Rock Island):—The report on the assignment, "Prepare rules for fire prevention as applied to railway property," is found on pages 388 and 389 of Bulletin 311.

We began our work of the study of fire prevention in terminals, as in terminals is found the greatest concentration of railway property subject to destruction by fire. Fire prevention begins with proper design. The data we present in Bulletin 311 covers points which the designer should bear in mind when planning a terminal—fire roads, the hazard from adjacent property, the fire lines of water supply, the possibility of drenching a certain area of lumber in storage yard to serve as a substitute fire break in absence of a sufficient vacant space for fire breaks, and other points of similar nature.

Our thought was: First, prepare rules covering design. Second, inspection. Third, maintenance. Fourth, protection of terminals.

The data on pages 388 and 389 covers design only, and is offered to the Association as information.

Chairman W. C. Barrett:—That completes the report of Committee XII.

The President:—This report is very much appreciated and the Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON YARDS AND TERMINALS

(For Report, see pp. 391-410)

Chairman J. E. Armstrong (Canadian Pacific):—It is my sad duty at this time to record the death on November 28th last of Mr. D. B. Johnston, Assistant Engineer Maintenance of Way of the Pennsylvania Railroad. Mr. Johnston was an active member of the Yards and Terminals Committee from 1911 until the time of his death. Your Committee wishes to pay tribute to a valued and loved member now no longer with us.

During the past year various sub-committees of this Committee have been collaborating with appropriate sub-committees of other standing committees in accordance with the requirements of the work in hand.

We gratefully acknowledge the help this Committee has received and hope that we have been helpful to the others with which we have come in contact.

At this time your Committee will submit certain conclusions in regard to Design of Coach Yards; a verbal report on the collaboration with Committee XX—Uniform General Contract Forms; certain matters as information in regard to facilities for Car-to-Car Transfer of L.C.L. Freight; certain information in regard to Scales; certain recommendations regarding Revision of the Manual with reference to test weight cars, and a verbal progress report on Practical Design and Construction of Humps in Terminal Yards.

The report on Design of Coach Yards will be presented by the Sub-Committee Chairman, Irving Anderson.

Mr. Irving Anderson (Atchison, Topeka & Santa Fe):—Assignment No. 2, "Design and Operation of Passenger Terminals, with particular reference to convenience and economy of operation of coach yards," will be found in Appendix B on page 393.

A questionnaire was sent to all the railways represented in this Association and this report is based on the returns from twenty-eight railways reporting on thirty-two different coach yards. This report deals primarily with coach yard facilities for handling through passenger equipment, some of which may not be necessary for handling suburban equipment.

The last time this subject of Design of Coach Yards was considered by the Committee was in 1902 and the discussion was printed in the Proceedings at that time. However, nothing was placed in the Manual.

The Committee proposes certain conclusions at this time for your consideration:

"(1) The coach yard should be placed convenient to the station and mechanical facilities.

"(2) The location of a coach yard should be determined by the economic balance between the following factors:

"(a) Available sites.
"(b) Land values.
"(c) Cost of construction.

"(d) Convenience to the station and other facilities.
"(e) Cost of moving equipment between station, coach yard and engine house.

"(3) The capacity required in a coach yards depends upon:

"(a) Number of cars and trains to be handled.
"(b) Class of equipment.
"(c) Standard of maintenance.
"(d) Length of layover.
"(e) Frequency of cleaning.

"(4) It is common practice to hold trains for cleaning and waiting for less than 24 hours on one track.

"(5) There are two general types of coach yard layouts; stub track and through track. There is also an intermediate type made up of through tracks, but operated generally as two systems of stub tracks. Operation is most efficient in a system of through tracks.

"(6) Tracks of equal length and equal to the length of the longest trains give greatest operating efficiency.

"(7) A spacing of eighteen feet between track centers has proven ample. Where land values are high, spacing may be reduced to 16 feet or to alternate spacing of 14 and 16 feet.

"(8) Tracks should be arranged in groups at the leads to facilitate switching. Auxiliary leads and tail tracks of ample length should be provided.

"(9) Nothing sharper than a No. 8 turnout should be used.

"(10) The gradient of coach yard tracks preferably should be level, but in no event should it exceed three-tenths per cent.

"(11) A wye or loop track should be provided for turning equipment. A loop track is more efficient but requires more space.

"(12) Special tracks for making-up or breaking-up trains are sometimes required.

"(13) Only light or running repairs are made in a coach yard.

"(14) The track-bed and platform-bed in coach yards should be well drained.

"(15) Platforms should be placed between all tracks.

"(16) The platform should be even in height with the top of rail. The edge of the platform should be five feet six inches from center of the track. The platform should be crowned three-sixteenths inch to the foot.

"(17) Water hydrants should be placed a minimum distance apart equivalent to the average length of cars. Usual practice is to place these in alternate spaces between tracks. However, there is substantial advantage in locating them between all tracks.

"(18) Hot water is usually provided in tubs at convenient locations.

"(19) Air connections for cleaning should be spaced the same as cold water hydrants; for testing air brakes, connections should be provided through a double connection at the center of each track or through single connections at each end of each track.

"(20) Electrical supply connections should be spaced the same as water hydrants, but a minimum distance apart equivalent to twice the average length of cars.

"(21) Steam supply connections should be provided in the same manner as air connections for testing air brakes.

"(22) A service building and storehouse should be provided.

"(23) At least one drop pit, serving two tracks, should be provided in large yards.

"(24) Provision should be made to store a sufficient number of car wheels.

"(25) There should be a building providing space for the necessary shop facilities.

"(26) Refuse disposal, fire protection and flood lighting should be provided."

I move these conclusions be adopted and placed in the Manual.

(The motion was regularly seconded, put to vote and carried.)

Chairman J. E. Armstrong:—A verbal report on collaboration with Committee No. XX—General Contract Forms, will be presented by Mr. H. L. Ripley.

Mr. H. L. Ripley (New York, New Haven & Hartford):—Committee No. XX has already reported on this subject. A tentative draft has been prepared in part and it is hoped and expected that it will be ready in due form to present to you at the next meeting.

Chairman J. E. Armstrong:—The report on the Design and Operation of Facilities for Car-to-Car Transfer of L.C.L. Freight, will be presented by Sub-Committee Chairman, L. L. Lyford.

Mr. L. L. Lyford (Illinois Central):—This report is found under Appendix C on page 400 of Bulletin 312. This report deals with various phases of car-to-car transfer and gives information as to the extent that separate facilities are provided.

As might be implied by this subject, it is only in comparatively recent years that the railroads have found it necessary to provide separate facilities for the handling of this kind of freight, due largely to the volume of traffic that has developed in recent years. This report includes a description of car-to-car transfer facilities of the Chicago, Rock Island & Pacific in their two yards in Chicago; the transfer facilities of the New York, New Haven & Hartford in the Cedar Hill yards; and of the Chicago & Northwestern Railway transfer facilities in Proviso, just outside of Chicago. The last-mentioned facility has only recently been completed and placed in operation, and the method of transferring package freight at this point undoubtedly represents the best that can be worked out under conditions existing on that railway.

You will note from the report that a questionnaire was sent to the principal railroads of the United States, and comparatively speaking, only a few provide this separate facility. Ordinarily this kind of handling is taken care of at the local freight house where the volume of business is not too great.

The three types mentioned in this report are typical of the different kinds which are used by the railroads, when it is found necessary to provide separate facilities. The substance of the report is given in the summary, and the report is submitted to the Association as information with the thought that the subject be discontinued.

Chairman J. E. Armstrong:—The report on Scales and Test Weight Cars will be presented by Sub-Committee Chairman, M. J. J. Harrison.

Mr. M. J. J. Harrison (Pennsylvania):—The part of the report dealing with Scales is found in Appendix D, pages 405 to 410, inclusive, of Bulletin 312, with particular reference to Weight Control of Test Weight Cars Used in Railway Service.

The first two and one-half pages of this report are largely discussion and I might say that this is the Committee's attempt to introduce a comprehensive discussion of this particular detail.

On pages 407 to 410, inclusive, is printed the matter which appears in the present Manual and also the proposed form. I shall read entirely the form as proposed by your Committee:

"Section VI—Test Weight Cars

"1. For general track scale testing, test cars should weigh not less than a total of thirty thousand (30,000) pounds, nor more than eighty thousand (80,000) pounds. For making graduated tests and to simplify calculations, cars weighing eighty thousand (80,000) pounds and forty thousand (40,000) pounds, respectively, are suggested. The maximum weight of 80,000 pounds is suggested principally in order to reduce the number of restricted movements due to weight limits on scales, bridges, etc.

"2. Test weight cars should have the following characteristics:

"(a) All metal construction.

"(b) Length of wheel-base not to exceed seven (7) feet.

"(c) Load distributed uniformly on wheels.

"(d) No unnecessary ledges or projections likely to catch and hold dirt.

"(e) No unnecessary parts.

"(f) Strength and durability, so that frequent repairs will not be necessary.

"(g) Surface area reduced as much as possible, to limit wind pressure.

"(h) Accessibility of all parts for inspection.

"(i) Roller or ball bearings of proper design, preferably the former.

"3. Test weight cars should preferably be of the self-contained type with solid body in which a small space is provided for a limited number of test weights. When it is impracticable to provide a self-contained car, a compartment car, with body of structural and plate steel, at least one-half of the weight of which consists of test weights carried in the compartments, may be found to be serviceable.

"4. Test weight cars should be handled on the rear end of trains, just ahead of the caboose.

"5. Test weight cars should not be kept in trains in yards during switching, but should be so placed that rough handling will be avoided. In no case should these cars be subjected to impact at a speed greater than two miles per hour.

"6. All excess weight, resulting from accumulations of snow or ice, should be removed from test weight cars before they are placed on scales for the purpose of testing or on a master scale for calibration. The use of steam is recommended for this purpose.

"7. Test weight cars should be calibrated on a certified master scale before being started on each general test trip, and not less frequently than once every three months. At the time of calibration, the actual weight of the car should be made equal to its nominal weight, which should be a multiple of 10,000 pounds.

"8. Each test weight car should be in the care of but one scale inspector between calibrations, and he should be held personally responsible for the maintenance of the correct weight of each car in his care. To this end, the following rules should be enforced:

"(a) No repairs to any test weight car may be made except in the presence of the scale inspector in charge thereof.

"(b) Journals of test weight cars may not be repacked unless directed by the scale inspector in charge thereof.

"(c) Each test weight car should carry a conspicuous badge plate, visible from either side of the car, and carrying a notice to the following effect:

" 'Do not oil or repack boxes or make repairs to this car unless directed by scale inspector.'

"(d) Should any change be made in the weight of a test weight car, it is the duty of the scale inspector to determine the amount of such change and immediately to make suitable correction. If the change in weight cannot be determined satisfactorily, the car should be returned to the master scale for calibration before again being used.

"9. The nominal weight of each test weight car should include the car proper and everything contained therein, excepting only such material as is specifically carried as supercargo. This material, consisting of tools, overclothes, etc., when carried, should be contained in a removable steel box, the outside of which should be stenciled to show that it is not a part of the test load. This box and its contents must be removed from the car when being calibrated and when used for testing track scales.

"10. When a test weight car is returned to the master scale for any reason, the actual weight of the car upon its arrival should be determined and recorded. Any unusual variation between that weight and the nominal weight of the car should be promptly and fully investigated.

"11. After the weight of the car on its arrival at the master scale has been determined, the car should receive any heavy repairs which are needed or may be needed before the next trip to the master scale, and should be thoroughly cleaned. At this time the axle bearings should receive any necessary lubrication and packing; after this has been done the car should be calibrated as outlined in paragraph 7 hereof."

Mr. President, I move the adoption of the matter just read as a substitute for the matter now appearing in the present Manual.

The President:—You have heard the report of the Sub-Committee on Scales. It has been moved and seconded that it be approved. Is there any discussion on this matter?

Mr. W. C. Barrett (Lehigh Valley):—I should like to ask the Chairman if the Committee would be willing to have a sub-committee of our Committee go over this matter which they have submitted. We do not want to trespass upon their preserves, but it seems that some of that matter might possibly go into the Manual of Rules.

Chairman J. E. Armstrong:—Does Mr. Barrett mean to have a consultation regarding including this as part of the Rules?

Mr. W. C. Barrett:—If you would be willing to co-operate with our Committee, that some part of it might be transferred to our Manual of Rules.

Mr. J. V. Neubert (New York Central):—I think this is a very excellent report. There seems to be some question in regard to the straight air cars. The standard cars now, I believe, have the straight air. A number of railroads have one and some another.

Mr. M. J. J. Harrison:—There is nothing specific said in this report regarding that particular feature. That was a subject which the Committee hesitated to mention at all in this report, being a matter which might possibly be considered as treading on the toes of the Mechanical Division of the A.R.A.; and also there comes in the Interstate Commerce Commission ruling of 85 per cent operative air in power braked trains.

I might say that the Committee has very definite opinions on this particular subject, which have not been expressed in this report. If Mr. Neubert has any thoughts that would aid the Committee in covering that point, the Committee would be very glad to have them.

Mr. J. V. Neubert:—The New York Central Railroad, as well as the New York Central Lines, have cars with air brakes. We have had the matter under consideration and advisement for quite a while. If I may be permitted to say it, I do not believe the Pennsylvania Railroad have brakes on the cars but have straight air.

Mr. M. J. J. Harrison:—You mean straight air, don't you?

Mr. J. V. Neubert:—Straight air, yes. We also took the matter up with the Bureau of Standards. We received a reply from them that the cars which they have and which, I think, operate east of Denver, or possibly west of there, have the straight air. They have had some controversy in the Operating Department, but after they have had some brief arguments, they have let the cars go through; in fact, the Bureau of Standards cars operate over the New York Central and we insist on air brakes. I was interested in the matter because we have had it under advisement for over six months.

The President:—Is there any further discussion on Mr. Harrison's report?

Mr. E. R. Lewis (Michigan Central):—It seems to me it would not look bad to have something about drainage at the beginning of this report.

The President:—You have the question before you. Is there any further discussion on the report? If not, those in favor of this report will please say "aye"; those opposed, "no." The ayes have it.

Chairman J. E. Armstrong:—The verbal progress report on "Practical Design and Construction of Humps in Terminal Yards" will be presented by Sub-Committee Chairman, R. J. Hammond.

Mr. R. J. Hammond (Boston & Maine)—1. Efficient operation of a hump requires a design which provides for a continuous flow of cars over the crest of the hump and the movement of these cars to their proper position in the different classification tracks without excessive shocks.

2. To obtain a continuous flow of cars, it is necessary that:

The track layout be designed to minimize interference with hump operation.

The gradients and curvatures be such as to minimize the effect of differences in rolling qualities of cars.

3. To insure the movement of cars to their proper position on the various tracks requires a series of gradients which will create sufficient acceleration to separate the cars at the crest quickly and carry them into the classification tracks without excessive speed, and a non-momentum gradient below the clearance point of the classification track.

4. With the introduction of car retarders it was found that certain features which were not important before became essential factors. Gradients based on train resistance studies were excessive. Since 1923 when the retarders were installed in the Gibson Yard of the Indiana Harbor Belt Railroad numerous individual car speed tests have been made. Your Committee has collected records of about 2,000 of these tests.

5. While there has not been sufficient time to analyze these and reach conclusions upon which to base recommendations to meet all the conditions to be encountered, the layout should be designed to:

(a) Separate the cars or cuts quickly at the crest.

(b) Divide the traffic quickly into as many streams as possible.

(c) Require minimum car travel between the crest of hump and clearance point of most distant classification track.

(d) Carry the poorest running car well into clear on the proper classification track under most adverse conditions without excessive speed at any time.

(e) Have body track gradients to carry the freest running car under most favorable conditions without excessive acceleration, to couple with other cars on that track.

(f) Decelerate cars at the end of classification tracks to prevent cars running out.

(g) Provide for uninterrupted movement of hump engines at all times.

6. The design of a hump layout must of necessity include the tracks as well as the gradients. Consideration must be given to many factors, among which are:

(a) Number of classifications.
(b) Maximum hump capacity required.
(c) Number of cars per cut.
(d) Types of cars handled.
(e) Number of cars scaled.
(f) Weight of cars.
(g) Variations in temperature.
(h) Velocity of wind and prevailing direction.

7. The car speed tests abundantly support the theory that the braking power required to stop a car increases in proportion to the square of the speed, and that the rate of acceleration of a car on a given grade decreases as the speed increases.

8. The tests have developed that generally a free rolling car will maintain its momentum on a 0.25 per cent gradient, and the effect of curvature on the average car was equivalent to 0.03 per cent adverse gradient per degree of curve; that an 8 to 10 per cent gradient would start a normal car; that the hump incline needs only enough length to separate the cars sufficiently so that switches can be thrown with comfort, and that by carrying the grades through the ladders less total fall and less braking effort is required.

The President:—The Committee is excused with the thanks of the Association for their most excellent report. (Applause.)

DISCUSSION ON RIVERS AND HARBORS

(For Report, see pp. 259-290)

(Vice-President Louis Yager in the Chair.)

Vice-President Louis Yager:—As you probably know, this is one of our younger committees. They are dealing with some very important subjects and they are our point of contact with some very important matters of flood control which are very much in the public notice.

The Committee's report will be submitted by the Chairman, Colonel Wm. G. Atwood.

Chairman Wm. G. Atwood (Consulting Engineer, New York City):—This Committee has been organized since the last convention, and has had a comparatively short time to work. Therefore this year's report is largely historical.

We were greatly assisted in the obtaining of data by the Corps of Engineers of the Army, the Bureau of Yards and Docks of the Navy, the Coast Survey and several other Government departments.

Two questionnaires were sent out to the railroads but the replies were not received in time to be tabulated and included in this year's report. The Committee has a large amount of data in hand which has not yet been digested and studied, but we hope to furnish a more comprehensive and more accurate report next year.

I will ask Mr. Hadley to present the report of the Sub-Committee handling river problems.

Mr. E. A. Hadley (Missouri Pacific) :—As our Chairman has stated, we have not made any recommendations this year, the Committee having only been organized during 1928. Our first work was to assemble data in regard to the several subjects assigned to us.

Subjects 1 and 2, "Report on Methods for Providing Against River Bank Erosion" and "Determine the Best Types of Construction for Levees and River Dikes for Flood Protection, Giving Recommended Dimensions," are somewhat related and the report of the Committee contains data which we have assembled, and which is of an historical nature. It describes what others have been doing, as in this instance we have not had time to make definite recommendations.

Subjects 5, 8 and 9, "Determine the Average Deposits in Fresh Water Rivers Bearing Silt and in Brackish Waters in the Tidal Range"; "Determine the Effect of Slight Salinity on Deposits of Silt in Rivers and Slips"; and "Study the Result of Deepening Channels on the Salinity of Rivers and Estuaries," are closely related but we have received insufficient data to make any report on these subjects.

The Committee has considerable information and replies to our questionnaires are still coming in, so that all we are able to report at this time is progress. We submit to you this information giving the experience and methods employed by others, which may be of some assistance to you in event you have occasion to use it.

Our studies will be continued and we hope to have some recommendations for the next convention.

Chairman Wm. G. Atwood:—The other section of the report on Rivers and Harbors will be presented by Mr. W. L. Morse.

Mr. W. L. Morse (New York Central) :—In the subdivision of this work on harbors it was necessary to send a questionnaire which was sent to all of the railroads and to the various departments of the Engineering organization of the United States Army, and from those we found 27 railroads that were without experience in regard to the various questions such as allowance for swell in scow measurement dredge work, allowable overdepth in dredging operations to obtain the desired operating depth, the usual slopes taken in deep waterways, and sounding methods in river and tidal waters.

But there were some 24 railroads that had had experience, and in addition we obtained information from the Washington, Boston, New York and Duluth offices of the United States Engineers' War Department, from the Navy Department at Washington, and also from the Department of Public Works, Commonwealth of Massachusetts.

It was indeed very difficult to set up direct and definite recommendations in regard to any of these matters for the reason that the character of material and the methods used vary in different localities, but based on the information collected we tried to summarize and put before you that which we considered to be of the most value.

For instance, in the allowance for swell in scow measurement, the character of material dredged determines the scow factor to be used, and that material varies in practically every location. Ratios vary not only from material but according to locality and method used.

Payment for excavation by dredging is usually made by one of two methods, namely, place measurement and scow measurement.

In maintenance it is customary to pay on the basis of cost plus an agreed profit.

For new construction or original dredging the following is suggested:

(1) Where possible, payment should be made on actual measurements obtained by soundings before and after dredging.

(2) Where local conditions do not favor payment by actual measurements, payment should be made by scow measurements with no allowance for swell.

(3) Where it may be necessary or desirable to allow and pay for swell, local conditions must prevail.

A fair allowance may be "Hardpan and sand, 0 per cent to 5 per cent. Sand and gravel, 5 per cent to 10 per cent. Clay and hardpan, 10 per cent to 20 per cent. Ledge, clay or stiff mud, a maximum of 30 per cent.

(4) Allowable over-depth in dredging operations to obtain the desired operating depth:

The allowable over-depth depends upon the character of the material and the depth of channel required. It must be governed by the type of plant used, the silting of streams and the desirability and economy of doing maintenance dredging at long intervals.

For channels in sand or soft materials, less than 24 feet in depth, 1 foot is allowed.

For channels in sand or soft materials, in excess of 24 feet, 2 feet are allowed.

For channels in hard materials with no chance of natural shoaling, 1 foot is allowed.

(6) Usual slopes taken in deep waterways:

The determination of side slopes actually assumed by different materials can be obtained only by observation. Current, depth of water, wave action and the presence of cross-currents, as well as different classes of material, determine the slopes. It is usual to base estimates on a 1 on 3 slope. Some material such as clay and hardpan will stand on a 1 on 2 slope, while sand will assume a flat slope, at least 1 on 5.

(7) Sounding methods in river and tidal waters:

Under this item we have given you the methods used where water freezes in the winter, such as give opportunities to go out on the frozen lakes or frozen rivers. We have given you the apparatus that may be used and the method of using that apparatus. We have given you different methods of laying out ranges from which soundings may be taken, and then we have given you, in a way, some of the results obtained from those.

There is practically no difference between harbor and river work except that there are occasions in harbor work where two sextants may be used from the boat instead of using transits on shore. This method allows the man in charge of the party to be in the boat and to detect at once if the boat is off range. When soundings are at a considerable distance from the shore, buoys are set on the range line where they can be used with shore points to make the sounding range definite.

It is the recommendation, and I move that the report covering the work of Committee B be accepted as a report of progress and the work continued the following year.

Vice-President Louis Yager:—The Committee is submitting some very interesting information, and they would like to have your comments or questions directed at the outline which they have presented.

Chairman Wm. G. Atwood:—The Committee, as in the case of all committees, wishes the assistance of the members of the Association that have data which will be helpful. This is, as has been stated, a new subject for the Association, and most of the data we present this year has been obtained from the Government departments.

We have no recommendations for inclusion of any material in the Manual as yet. Therefore, we do not ask for approval of anything but merely for assistance in the next year's work.

Mr. P. T. Simons (Missouri Pacific):—It occurs to me that an assignment of work to a committee which is to consider flood control should include the subject of drainage and the function of river channels. Drainage in its broad sense is the mode by which the waters of a country find their way to the sea. The primary function of river channels is to carry runoff, a drainage function. Under that definition of drainage, flood control is a part of drainage, that is, it comes under drainage.

I do not find in the assignment to this Committee any reference to the foregoing broad definition of drainage. My study of this subject during the past twenty years, and particularly discussion of drainage and flood control at the National Drainage Congress which met at Memphis two weeks ago, have brought out that definition clearly to my mind.

It seems, with present assignment, the name of this Committee should be changed to "Committee on Harbors and Stream Control," or, if the Committee is to consider rivers in relation to flood control, then at least one subject should be assigned to cover drainage in its broad meaning.

I believe a committee of this Association might accomplish much good for drainage and flood control by placing before the Association membership a concise definition of the function of river channels, drainage. I would like to suggest that this matter be considered by the Committee on Outline of Work.

Vice-President Louis Yager:—We are glad for that suggestion, and it will be placed before the Outline of Work Committee for consideration.

Are there any other comments directed toward the subject? If not, you may proceed, Mr. Chairman.

Chairman Wm. G. Atwood:—I think we have nothing more to present.

I might say in connection with Mr. Simons' remarks, that without consulting the Committee, it is my own feeling that drainage is not part of the assignment of this Committee up to date, that we are merely assigned to matters in connection with protection so far as streams are concerned, and that the large subject of flood control is not entirely included in our assignment.

Vice-President Louis Yager:—If there are no further comments, the Committee is excused with the thanks of the Association for its very commendable beginning of progress. (Applause.)

DISCUSSION ON WOOD PRESERVATION

(For Report, see pp. 653-702)

(Vice-President Louis Yager in the Chair.)

Vice-President Louis Yager:—The report of the Committee on Wood Preservation will be found in Bulletin 313. The report will be submitted by Mr. F. C. Shepherd, the Chairman.

Chairman F. C. Shepherd (Boston & Maine):—The report of Committee XVII—Wood Preservation is found on page 653 of Bulletin 313. The list of assignments are shown and reports are given as follows:

Revision of Manual, Appendix A, is shown on page 655. I will call on Dr. von Schrenk to describe this report.

Dr. Hermann von Schrenk (New York Central):—The Committee on Revision of the Manual has only one recommendation to make this year, which appears on page 655, namely:

"Eliminate paragraphs (c) at the bottom of page 110, top of page 111, Bulletin 288, Supplement to the Manual, and substitute the following: 'A galvanized-iron shield lined with one-eighth inch asbestos of the form and dimensions shown in Fig. 10 shall be used to protect the flask from air currents and to prevent radiation. The cover (top) shall be of transite board made in two parts, or it may be of galvanized iron lined with one-eighth inch asbestos.'

"Also substitute the accompanying drawing of the shield for the drawing shown as Fig. 10, page 111, and substitute the accompanying drawing of the apparatus assembly for Fig. 11, page 113."

I might add that this recommendation will bring our standard method of analysis in line with the work which has been done on a co-operative basis between the committees of the American Railway Engineering Association, American Wood Preservers' Association, and the American Society for Testing Materials, and we trust this will possibly be the last change for some time.

I move you, sir, that the recommended change be approved for printing in the Manual.

Vice-President Louis Yager:—There is a motion and a second before you that the change in the Manual just described be approved. Is there any discussion? If not, those in favor signify by saying "aye"; contrary "no." The revision is adopted.

Chairman F. C. Shepherd:—The report on Definitions Used in Wood Preservation, Appendix B, is shown on page 657. This is submitted as an additional list to the list presented at the last meeting, it being planned, with the two lists combined, to present a final report in another year. If there are any comments or additions to this list, the Chairman, Mr. E. B. Fulks, would be pleased to receive same from any of the members, in writing. This report is filed as information only.

Report Upon Service Test Records for Treated Ties, Appendix C, is shown on page 662, carrying with it a table of tie renewals per mile brought up to 1927, additional records from the Forest Products Laboratory, fence post tests on the Santa Fe, and special test track reports on four roads. This is presented as information.

Vice-President Louis Yager:—Are there any questions any of you would like to ask the Committee in connection with these test records?

Chairman F. C. Shepherd:—The Report on Piling Used for Marine Construction, Appendix D, is shown on page 667.

The Sub-Committee submits its report on the recent inspections of the long-time test pieces prepared by the Chemical Warfare Service, some of its own members, the Army, Navy and other co-operators. This report is submitted as information.

Vice-President Louis Yager:—Are there any questions any of you would like to put to the Committee on this appendix?

Chairman F. C. Shepherd:—The reports upon the Effect of Preservative Treatment by the Use of Creosote and Petroleum, Appendix E, page 683, and Appendix F, Use of Zinc Chloride and Petroleum, page 683, simply state that the Committee has no information to present this year, but requests that the subject be continued for further investigation.

Report on Specifications for Treatment of Air-Seasoned Douglas Fir, Appendix G, shown on page 684, is presented after a very exhaustive trip and inspection by the Committee during the summer of a large number of bridges containing creosoted Douglas fir. This report is offered as information. If there are any questions, Mr. Belcher will be very glad to explain what was found on this trip and what the conditions are.

Vice-President Louis Yager:—Are there any questions in connection with the last subject or any of the preceding ones?

Chairman F. C. Shepherd:—Mr. Chairman, in concluding our report the Committee wants to note with deep regret the loss of one of its oldest members, and one of the pioneers in the wood preservation industry, Mr. J. H. Waterman, who died last month.

The Committee has no further report, Mr. Chairman.

Vice-President Louis Yager:—The Committee on Wood Preservation is excused with the thanks of the Association for its very creditable work. (Applause.)

DISCUSSION ON STRESSES IN RAILROAD TRACK

(For Report, see page 1228)

Dr. A. N. Talbot (University of Illinois):—The Committee's report is a report of progress; it is to be found on page 1228 of Bulletin 314.

It had been expected that a report of considerable volume would be ready for publication before this time. It was found, however, on account of the amount of the material and the complexity of a considerable part of it, that to attempt its publication before the time of this meeting would necessitate leaving part of the proposed report in an incomplete condition. The Secretary, too, I think, was glad to have the expression of the Committee asking that publication be postponed. The plan now is to have the report printed in a Bulletin of the Association during the summer. The material presented to the Committee on Stresses in Railroad Track already under consideration involves something like 25 tables, over 100 diagrams, and 250 typewritten pages.

The report already written deals with the rail-joint and with the general conditions of track that were found in the test of track made in the study of the rail-joint. It is divided into the following parts: the general structural action of the rail-joint, which is an attempt to find what goes on in the rail-joint and in what way its action should be thought of; the mechanics of the rail-joint, which deals with the mathematical and analytical treatment of it; the laboratory tests of the rail-joint, which are not the usual tests of joints to find the ultimate load they will carry, but instead are intended to learn about the stresses that are developed, where they are developed, and what movement takes place in the joint, and also what differences of action are found in different types of rail-joint; and last, the field tests, tests having been made on track of five railroads with heavy loads applied and measurements made of the stresses and vertical movements in the rail-joints, the depressions of the track and the variations in conditions from joint to joint, a sufficiently large number of joints being tested to find what variations in action may be expected.

The portion of the report not yet completed, the part which has delayed its presentation, includes a general discussion of the information obtained and its application to the rail-joint problem.

The subject-matter, as I have indicated, is extensive and rather complicated. An attempt has been made in the presentation of it, however, to simplify it as far as possible and to deal with general conditions. I am sorry that the material is so complicated that it does not seem proper or practicable to attempt to present to you the results this morning. The Committee itself had this material for several weeks before we held a two-days' meeting to discuss it, and I know from their experience in that time and with those facilities that you would not want me to attempt to present it now, even though the Chairman tells me that we have available time before us.

I may say, however, that in the study of the action of the rail-joint, it is concluded so far as vertical loads are concerned and vertical bending moments that the joint bars in all the rail-joints tested act as beams, as simple beams loaded near the middle, an inch or so back from the rail ends and are supported on the base of the rail some distance back of that, the distance varying with the conditions of the joint, but the centers of the supports being, say, eight inches or so away from the rail ends in each direction. Beyond that bearing area there may be a loose bearing contact, if the joint is a loose one; the support bearings will be farther back from the rail ends than if the joint is tight and well fitting. These distances then indicate that the main length in which the joint functions, when it is in good condition, is, say, less than 20 inches of total length and that the two bars act as beams within that length.

An important element in the action of rail-joints is the fit. By fit is meant a very close connection between the head of the rail and the top of the bar and between the base of the rail and the bottom of the bar. It is a question of a few thousandths of an inch, perhaps, as affecting whether there is a vertical movement between the head of the rail and the bar, when the load is applied. The measuring gage, or thickness gage, was inserted in many places between the head of the rail and the top of the bar, and the amount of the movement during loading was found to be an indication of the way the joint acts.

The sum of the vertical movements between bar and head of rail at the two ends of the rail and at the two ends of the bar added together (the sum varying from a few thousands to a few hundredths of an inch) may be said to form an index of the action of the rail-joint in track. Regardless of the type used, the joint with an excellent fit evidently develops a higher bending moment, a moment more nearly representative of the bending moment that is developed in the rail at points away from the joint, than is the case when the bars have a poor fit and permit a considerable amount of movement between bar and rail.

The magnitude of the vertical movement between bar and rail (or lack of magnitude rather), then, is an important attribute of what may be thought of as the effectiveness of a rail-joint (I won't say efficiency) for judging how closely desired conditions are approached.

In addition to this vertical movement, with types of bar that are not symmetrical with respect to a horizontal axis, the angle bar, for example, there is also a lateral movement taking place on the application of load. At the top of the bar near the ends of the rail, the bar has contact with the head of the rail when a load is applied. Below this contact area the bar is not in contact with the base of the rail, and the bar tends to deflect inwardly toward the rail or to twist in that direction, or both. The effect of this lateral movement or twist may be a considerable increase in the maximum stresses developed at the middle portion of the length of the bar.

We should expect, I believe, that a joint that is operating well will have developed in it under the same conditions of rail support (ties and ballast) about the same bending moment as is developed in a full rail under ordinary conditions, or under the same conditions. This has been taken to be the condition that should be approached as nearly as possible. And yet it is found that in some of the joints tested in track, the actual moment developed in the joint was not more than 20 or 30 per cent as great as that which would be expected in the full rail itself. Still more frequently the moment in the joint is 20 or 30 per cent less than that in the rail itself opposite the joint. These conditions are due to conditions at the joint, perhaps to the design of the joint; these are taken up in the report.

The bending moment in the joint bars, of course, is the greatest at the rail ends where the rails take no moment; it decreases from there to the points of support of the joint bars. The joint should be made and supported so that, as I have said, the magnitude of the moment developed will be the same as that in the rail opposite. If not, there will be more depression, deflection or movement, which will eventually result, of course, in undesirable conditions at the joints.

Tie support enters into this. Of course, in the laboratory the full bending moment is applied and the joint bars have to take whatever moment is put on, but in the track the resistance of the ties and the stiffness of the reaction of the ballast affect the amount of moment developed in the joint. The reaction of the tie depends upon, first, whether the rail is originally in contact with the tie and the tie in contact with the ballast, and second, what the support of the tie is as affected by the stiffness of the ballast.

Naturally, in the track the ballast conditions vary from point to point, but after all a great part of the variation is due to two things: First, the spacing of the ties; and, second, the tamping of the ties and the stiffness of the tie support. It has been difficult to get at the measure of the latter.

The tie spacing, of course, we can see very definitely, and closer spacing naturally gives a stiffer support than is available where the ties are not so closely spaced. With such variations must go this: the more support and the more stiffness immediately under a rail-joint the less the moment developed in the joint bars and the less the joint is called upon to do, just as under the same condition of tie spacing and bedding the rail is called upon to do less in resisting bending moment.

It is apparent, too, that in the tie tamping the stiffness of the ballast underneath is increased after repeated tamping. The harder and stiffer it is, the greater the amount of reaction taken by the joint ties as compared with the ties adjacent to the joint at one or both sides. Although the difference may appear to be small and may not be recognized by engineers in charge who say that the track men have rigid instructions not to tamp the joint ties more than others, something has happened to the track, at any rate—either they tamp the joint ties more, or they tamp them better, or something else, for there evidently is a generally greater resistance to compression underneath these joint ties than is found elsewhere.

Another evidence of the greater support given by the joint ties may be noted. As you know, with stiff rail and good ballast, the rail itself while under no load is supported at only three or four points in its length. Every three or four or five or six ties there is a bearing. By making measurements and making comparisons, it was found on an average that the ties right at the joint (the middle one of the three if it is a supported joint, the two joint ties that are a little closer together, if it is a suspended joint) hold the rail, or the average distance between the tie and the rail in the unloaded condition is less there than elsewhere. This was not found merely by going along and sighting and making measurements. It was found by a rough-and-ready test method of what we called pick-up and push-down. The tie was pushed down to find whether there was any particular distance between the bottom of the tie and its bed in the ballast. Next, the tie was pulled up, lifted, to see how far it would move before it touched the rail. These measurements form the basis of the remarks concerning what ties really support the rail. Naturally, of course, if there is less distance between the rail and the tie at any given point than at another point, the tie which is closer will take a larger proportion of the load applied through the rail.

These differences are rather small, but they are very significant; in fact, one of the strange things in connection with the tests was that small variations in dimensions, in movement, in position, made on an average a large difference in the results obtained.

Of course, we all believe that the condition of the ballast under the ties has a considerable effect upon the action of track. It is apparent from the tests carried on that deep ballast, well compacted ballast, ballast that has been in place for a long time and has become compacted, is an important element in favoring the action of rail-joints, in influencing the action of the track so that even under unfavorable conditions the track does not go to pieces. This, at least, is the only explanation that we have for track keeping up fairly well with joints that are only mediocre.

I trust that what I have said will indicate the diversity of the topic that the Committee is now engaged in treating. I wish to express the hope that with the Bulletin coming out in the summer many of you will take the opportunity to make a study of it and that we may have a thorough discussion of the subject of rail-joints at the next annual meeting of the Association. (Applause.)

Vice-President Louis Yager:—Thank you, Dr. Talbot, for the very interesting forecast of your report. I am pleased to announce that we have with us one of our own members and the President of a kindred society, Mr. Elmer A. Sperry, President of the American Society of Mechanical Engineers, known to you no doubt through his extended inventions, such as the gyroscope, and of much more immediate interest to you is the development of the transverse fissure detector car.

I believe Mr. Sperry has some remarks to address to the work of this Committee.

Mr. Elmer A. Sperry (President, American Society of Mechanical Engineers):—I do not know exactly whom to address here, but I certainly can not make a mistake when I address our dear Doctor who has just spoken. As was my ill-fortune when I was elected President of the American Society of Mechanical Engineers, I had to follow Charlie Schwab, and who can follow Charlie Schwab? Here I am again. How can I follow our experienced Doctor? I am sure I feel as if I were trespassing on this matter of rail stress.

I feel that there is a very definite and important relation between stress in rails and the development of fissures. Such fissures as are developed through fatigue phenomena are certainly due to stress. We have gone far enough now with the two cars to be astonished by what we find. It does not seem to follow some of the laws that we expected. We expected to find that these fissures developed along the line of the heats at the mill. Now we find they do and, again, in places we find that they do not at all. They seem to have a tendency to follow along the line of regional distribution.

What can that possibly mean? It seems to me that this points to some condition of the ballast or sub-ballast as foundation of the track.

Conjointly with this work, the fine Santa Fe engineers have been very helpful to us. I do not know how to express my appreciation to all of my friends, I am sure, but they allowed us to come to Car 20, the track inspection car with the gyroscope on it. We put a special attachment on that car by means of which we could search the surface of each rail. For each rail we made a line two inches long, representing exactly what the surface of that rail looked like, not when the track inspector, track walker, or section boss looked at it, but when it was under condition of heavy loading. There seems to be all the difference in the world between these two conditions.

As the good Doctor has just said, excess stresses depend upon minute matters, but we found that they were not so minute. The track was one thing when you looked at it, but when you jumped on it, it was quite another thing, especially when we took curves at high speed with the heavy car. Mr. Chapman can tell us what that car weighs, about seventy tons, I think. You can quite appreciate what would happen to a track under these conditions, especially in soft places or where it is under condition of poor sub-foundation, poor tamping, etc. Of course, I am not expert when it comes to this subject, but these observations we have made may throw some light on the matter.

What did we find? We took a space on the chart that reeled out 13.2 inches per mile, but we got the surface of the track with two inches per rail, 160 rails to the mile going down the track as high as sixty miles an hour. By going back and forth on that chart once for every rail, we had 160 lines each 2 inches long, and by casting your eye along down the alinement, you were instantly struck by any variation from an exact straight line.

Now, then, there is where the surprise came in. These fine tracks with hard, glassy surfaces, which looked in perfect alinement, when jumped upon were found not to bear up and remain in alinement. In localities the track had humps in it and had hollows. These were plainly to be seen and the rails easy of identification. So here is a thing that I feel might explain some of these observations that we have made with regard to fissures being developed in regional localities. Mr. McDonald the other night said that he had gone through something of the same experience years ago. So I feel that not only rail-joints, but the sub-foundation of our tracks cannot be too well looked after. I have no doubt you have known this for years, but we have now actually got a picture of what these rails, that seem perfectly straight and wonderfully smooth, become under loading and heavy impact at high speed. We can see that there are strains and stresses in some of these rails that we haven't suspected, and I think we have got to take care of that as well as the joints.

I think that is about the message that I wanted to get over to you. If I am correctly informed about the mileage of the two fissure detector cars, we have now a record that we can go back to, find the identical rail and see exactly what is inside of it, of a little more than one-half million rails in track. This shows exactly what the size of the fissure is, just where it is located, including also horizontal fissures, split-heads, and other defects, that we hardly expected to be able to detect and record when we started. I thank you. (Applause.)

Vice-President Louis Yager:—Are there any others who would like to be heard on this subject? We regret very much that the intricacies of the subject, as it developed in the later stages, prevented publishing the report of this Committee in time for this meeting. Dr. Talbot has given you a very good forecast of what is in store for you, and those of us who have been privileged to see some of the preliminary results can be assured that you are going to have something for which you have been waiting a long time. That is some experimental data which will set us straight in the design of joints, which, as you know, has heretofore been confined very largely to mathematical analyses.

The Committee is excused with the sincere thanks of the Association for its very commendable work. (Applause.)

DISCUSSION ON GRADE CROSSINGS

(For Report, see pp. 487-507)

Chairman Frank Ringer (Missouri-Kansas-Texas Lines):—Your Committee IX on Grade Crossings desires to express regret that the illness of its Chairman, Mr. F. J. Stimson, has prevented him from participating in the year's work, and to express the hope that he may be speedily restored to health.

The report is printed in Bulletin No. 312, beginning on page 487. Referring to page 487, Subjects (2), (4) and (8), further consideration of these three subjects was deferred in view of the action taken by the Association at its last convention.

The report of Sub-Committee (1) Revision of the Manual, as printed on page 489, will be presented by Mr. Maro Johnson, Chairman of the Sub-Committee.

Mr. Maro Johnson (Illinois Central):—Following the action of the 1928 convention, the Committee has given further consideration to the Highway Crossing Sign, particularly with reference to the use of an auxiliary sign indicating the number of tracks to be crossed, and has again submitted same to the membership for letter-ballot.

Since the results of this ballot were printed in the Bulletin some additional votes have come in, so that the total number is now 1102, of which 670 favored the Highway Crossing Sign *with* indication showing number of tracks to be crossed; 329 favored the Highway Crossing Sign *without* indication showing number of tracks; 89 were against the Highway Crossing Sign, and there were 14 ballots which could not be interpreted or not signed.

This Committee, therefore, recommends the adoption of sign shown on page 490, for publication in the Manual as recommended practice. I move its adoption.

The President:—It has been moved and seconded that we adopt the report as presented by Mr. Johnson, shown on page 490, and place it in the Manual. Is there any discussion or observation on this particular item?

Mr. G. D. Brooke (Chesapeake & Ohio):—The sign provided for flashlight crossings has one character of crossbuck. The plain sign has another. It seems to me very desirable that, if possible, the same type of cross-arms be used on both signs, for the reason that this sign to a rapidly passing motor vehicle is more in the nature of a conventional sign rather than what appears on it. From rapidly moving vehicles it is impossible to read the lettering correctly, and it would seem to me very desirable to have the same design, to catch the eye, for both signs.

I have been discussing this with some of the signal men and they are particularly anxious that the arms on the flashlight signs be kept within certain limits so that the location of that sign can be placed either in the center of the highway or close on the side of the highway. The note referring to the flashlight sign indicates that the design of the crossbuck is to be the same as that for the plain sign. That would make it impracticable to use this sign in the center of the highway or to put it as close to the center of the highway as if a shorter sign were used.

Mr. J. C. Mock (Michigan Central):—This crossbuck sign is rather out of style. It cannot be installed in the center of the highway because it is too long. That is also true for locations at the curb. I would prefer the 90 degree type sign shown in Appendix B.

The President:—You have before you the sign which has been presented by this Sub-Committee in connection with highways. This question is of very vast importance in view of the increasing number and amount of rural and interstate highway mileage, and also the possible recurring and increasing number of railroad grade crossings and the like.

I will ask Mr. Ringer to make any remarks, and either he or Mr. Johnson will answer these two observations.

Chairman Frank Ringer:—With reference to the first gentleman's remarks as to the length of the sign, a good many of the states specify dimensions of letters which are required on the crossbuck sign, requiring a longer blade than is used on the flashing light type of signal. I believe it would be rather difficult to reconcile the two.

Mr. G. D. Brooke:—If that situation were not the case, what would be the Committee's view of the matter?

Chairman Frank Ringer:—That would be a condition that the Committee has not so far considered and which, under the circumstances, I do not believe should come up here. Of course, it would be desirable to have uniformity in the signs. I do not think there is any question about that.

Mr. Hadley Baldwin (Cleveland, Cincinnati, Chicago & St. Louis):—I have had some experience on this Committee that is reporting. I think this sign ought to be adopted, or some sign of this general character, independently of considerations for the smaller crossbuck sign that goes on the flashlight signals. A great majority of the crossings in the country are equipped with only a sign of that character, but of widely varying types. It is a sign that identifies the presence of a railroad crossing at a distance more effectively than anything that has been conceived, except outside approach signs along the highway.

The crossbuck sign that goes on the flashing signal has a supplementary value rather than a major value. The flasher signal is conspicuous when a train is approaching, and the crossbuck helps to identify it as a secondary proposition, as I see it. But these crossbuck signs that are intended to apply all over the country, throughout the rural districts where there will be nothing else in the majority of cases for many years, ought to be standard. I am convinced that this form of sign should be adopted.

Mr. Robert H. Ford (Chicago, Rock Island & Pacific):—I want to endorse all that the previous speaker has said about this sawbuck sign. I think there is a misapprehension on the part of one or two of the speakers with respect to the sign and its purpose, as brought out by Mr. Baldwin. This is a universal sign. There is a great need of standardization of practice throughout this country with respect to a crossing sign.

I think one of the main advantages by the adoption of this report, as made by the Committee, is that it will permit some uniform legislation being established throughout this country with respect to this sign. As it stands today, there are a number of states that have various kinds and various types of signs. The Committee has done a great deal of work on this sign. I do not know of any piece of research work that has been so thoroughly canvassed and so thoroughly studied as this sawbuck sign. It has been pending before this convention a long time. It has been taken back and reviewed again and again, and finally it has been submitted to a vote of the membership.

I want to commend the Committee on the thoroughness of the work they have done and concur in the recommendation, and I hope the report will be adopted. It will be one step, and a very big one, in the question of standardization in practice with respect to railway grade crossing signs.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—If I correctly understand the situation, the question involved here is not that of the sawbuck sign. It is whether or not a supplementary sign shall be placed on it indicating the number of tracks to be crossed.

That question came up at the last convention and it was referred back to the Committee because the convention could not agree on the question of whether we should put this supplementary sign there. The Committee has taken a vote and the majority has decided in favor of the fixing of this supplementary sign. The actual sawbuck sign as it appears here has been a standard of this Association for a great many years.

Mr. J. C. Mock:—This crossbuck sign is old style. It cannot be used on crossing signals such as wigwags or flashlights because it is too long for center of highway location and not desirable for curb locations. We found it necessary to change to the 90-degree design on account of clearance requirements. For the sake of uniformity it would seem to be better to adopt the one shown in Appendix B for all locations.

The President:—Are there any further observations in this matter? If not, the Committee and the Chair understand that the issue brought up is this: A definite matter is before you in regard to putting on the plate an indication of the number of tracks on the sawbuck sign. The sawbuck sign has an angle of 50-degrees between the blades. In a report which has not been presented, but which will be presented later on, is the flashlight and wigwag signal with blades of 90 degrees.

The prime issue before us is that of the sawbuck sign with the plate number on it. Of course, it is well to bring up these two issues together, as the second report brings up the other sign. The Committee itself is willing to omit the degree angle of 50 degrees shown between the blades, leaving it to the discretion of those who care to adopt an angle different from that shown.

The question first before the house is the issue of the sawbuck sign with this plate, and we have drawn it into a matter of consolidating that sign with the sign that appears in the next appendix.

At this point I shall let Mr. Ringer speak for the Committee.

Chairman Frank Ringer:—Mr. President, the Committee understands that it is governed in this matter by the letter-ballot which was taken during the last season, and which was in favor of the adoption of this sign as submitted to you; and in view of the instructions and action of the Association at the last convention, the Committee has not felt at liberty to make any further changes in the sign, and presents it for adoption as a result of the letter-ballot.

Mr. C. C. Cook (Baltimore & Ohio):—If we are pursuing the ultimate in simplification it seems to me we would have to consider with the flashlight crossing sign, the addition of the board showing the number of tracks; and it might be possible for this Committee to harmonize these two signs so as to get the approval of the Association for the flashlight crossing sign, with the addition of the number of tracks.

Mr. Robert H. Ford:—I hope that will not prevail. I have something to say on this flashlight signal when the time comes, but I trust the issues will be kept clear and distinct.

First is the adoption of the Committee report on the sawbuck sign with the number of tracks, as stated by the Chairman. I trust that the Chairman of the Committee will hold to his plan as made and not change the angle. I am asking for it simply in the line of standardization throughout this country. I think the time has come now when we ought to get some positive, direct action.

The President:—Is there any further discussion on this particular Sub-Committee report? If not, the issue is clear and the Committee desires to put it up straight on the issue of the sign as presented here in this Sub-Committee report. It will then fall or stand on the merits of that particular issue.

It has been moved and seconded that the sign as presented is to be adopted as the practice of this Association. Your vote will be "yes" if you approve it. I shall now put the question: Those in favor of the adoption of this particular Sub-Committee report, will please say "yes"; those opposed will say "no." The ayes have it and it is approved.

The remainder of this Committee's report will be taken up at two o'clock sharp. In view of the special order of the day, this Committee's report is not complete, but we will adjourn until two o'clock.

Intermission

WEDNESDAY AFTERNOON

(Past-President J. L. Campbell presiding.)

Past-President J. L. Campbell (Northwestern Pacific):—The report of the Committee will be continued by the Acting Chairman, Mr. Frank Ringer.

Chairman Frank Ringer:—Subjects 3 and 7 have been considered by one Sub-Committee. The report is on page 491 of Bulletin 312. Subject (3): Study and report on the comparative merits of various types of grade crossing protection, collaborating with Committee on Signals and Interlocking, and Subject (7): Study and report on various types and locations of approach and warning signs for grade crossings, also the practices in the several states and federal requirements, with a view of securing uniformity of practice and standards.

The report of this Sub-Committee will be presented by Mr. Bernard Blum, Chairman of the Sub-Committee.

Mr. Bernard Blum (Northern Pacific):—The work of this Sub-Committee has been to continue the study started about two years ago. While some of the conclusions that were reached were presented before the Association last year, no definite action was taken and the matter was referred back to us.

This Committee has co-operated with Committee X—Signals and Interlocking, and some of the conclusions which I shall refer to later follow the recommendations and work of that Committee. The principal work of the Committee has been to devise signs for grade crossing protection, and we shall present definite conclusions to you for action. We have also been giving consideration to other forms of grade crossing protections which are covered in the text on pages 491, 492 and 493 of the Bulletin. We have likewise worked up and presented data on grade crossing accidents, and while the results during the past several years have not been all that might be desired, I think that these tables indicate that we are beginning to get some results out of the work that the railroads have been doing.

The number of accidents per thousand vehicles has begun to show a tendency toward decrease or, rather, an increase in the number of vehicles per accident.

Other information contained in the report is apparent.

In conclusion, we have three recommendations to present to the convention, and I will read them one at a time and call for action.

"1. We recommend that the flashlight, Fig. 1, or wigwag signal, Fig. 2, on pages 497 and 498, be adopted and placed in the Manual as recommended practice for installation at busy crossings and for replacing gates and watchmen."

Past-President J. L. Campbell:—You have heard the motion. Is there any discussion upon it?

Mr. Robert H. Ford:—I think the Committee have done excellent work. It has occurred to me, however, on Fig. 1, that perhaps there may be a misunderstanding on that figure. I notice at the top of the page they have the sawbuck sign marked "A.R.E.A. Standard Crossing Sign."

If you will refer back to page 490 you will see that the point made this morning about the angle of the sign makes it impracticable to utilize that, and in that respect I think the suggestion made by Mr. Brooke as to what the Signal Section felt about it is well taken.

I am wondering if the Committee recognized that in the flashing light signal the controlling features are the flashers and not the angle of the sign, or, in other words, the purpose in the installation of the flashing light signal is to keep the sawbuck sign within the range of the extent of the flashes, and the angle of the crossing has little or nothing to do with it.

It seems to me that the first thing the Committee ought to do is remove those words, "A.R.E.A. Standard Crossing Sign," because I do not think it means exactly what they have in mind.

The sawbuck sign is a sign and I think that is what they refer to. If they change that it would improve it, although I believe that the sign would be helped greatly if the controlling feature, so far as the angle is concerned, was shown as within the limits of the flashers and which is not shown on the diagram.

Chairman Frank Ringer:—It will be agreeable to the Committee to eliminate those words, Mr. President.

Past-President J. L. Campbell:—The Committee accepts this suggestion. Is there any further discussion?

Mr. A. H. Rudd (Pennsylvania):—Do I understand, then, that the right angle is not A.R.E.A. standard? My understanding is that we have adopted two standards.

Chairman Frank Ringer:—The standard adopted this morning provides an angle of 50 degrees.

Mr. A. H. Rudd:—That was also adopted a year ago.

Mr. Bernard Blum:—I did not object when Mr. Ford brought up the point of leaving out the designation of the sign because there might be some confusion with the sign as shown on page 490. Personally, I do not think it is of importance to have this flashing light have the newly adopted sign or have the wording that this is the A.R.E.A. Standard Crossing Sign.

Mr. A. H. Rudd:—I think the Manual gives the size.

Past-President J. L. Campbell:—Is there any further discussion?

Mr. Robert H. Ford:—I have one other suggestion to make. Page 492, in the second paragraph from the bottom of the page, I should like to ask the Committee if they are agreeable to making this insertion. I will read the paragraph as it is, or rather the last half of the paragraph:

"The advantages of having the home signal in the center of the roadway to divide the traffic, reduce speed, and avoid any question of the automobilist seeing the sign, has appealed to many railway engineers."

The Committee is merely making a statement of fact; they are not making any conclusion about it. I think they are wise in doing it at this time because there is wide diversity of opinion concerning the center installation.

But that is the purpose of the center installation, and by the insertion of those words, it meets the main feature which is claimed by the opponents of center installation, and that is: "thus securing the compulsory contributary action on the part of the user of the highway." If it is agreeable to the Committee, I hope they will insert that.

Past-President J. L. Campbell:—The Committee says it has no objection to the insertion of these words, and they will be inserted, unless there is objection from the floor.

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—The point is one of grammar. The way it now reads is "the advantages . . . has" instead of "the advantages have" or "the advantage has." This should be changed.

Mr. Robert H. Ford:—I recognize that, but I assumed that the Committee will strike it out themselves.

Mr. Arthur Ridgway (Denver & Rio Grande Western):—I understand there is some doubt, some question, about the uniformity of color signal indications, or color indication on the highway. What colors are these lights in this flashing light signal?

Mr. Bernard Blum:—I do not recall offhand whether the Signal Committee has a standard colored lens for the signs. Did you mean whether red, green, yellow or orange?

Mr. Arthur Ridgway:—Should it not specify on this sketch as to the color?

Mr. Bernard Blum:—I thought Mr. Ridgway had in mind certain tones of red. It is to be a red lens. There are no objections to having it indicated on the drawing.

Past-President J. L. Campbell:—This suggestion is also accepted and will be incorporated. Is there any further discussion?

(The motion was put to vote and carried.)

Mr. Bernard Blum:—We recommend that the advance warning sign as shown by Fig. 3 be approved as recommended practice and placed in the Manual.

(The motion was put to vote and carried.)

Mr. Bernard Blum:—We recommend that wherever wigwag or flash-light signals are used, two shall be used at each crossing, one on each side of the track, and that in cities and towns, when the street is of sufficient width, the signals shall be located in the center of the street. Recommended practice is shown in Fig. 4 and Fig. 5.

I recommend that this be approved and included in the Manual as recommended practice.

Mr. A. H. Rudd:—I should like to ask the Committee if they are willing to omit the words, "and that in cities and towns, when the street is of sufficient width, the signals shall be located in the center of the street." I am making that suggestion because, as a member representing the railroads on the American Engineering Council, we have had a good many sessions and the Council has presented its report, and its recommendation for traffic signals are as follows:

"All traffic control signals should be so placed that the lights are plainly visible to the traffic to be directed.

"The type and location of lights should be as follows (named in the order of preference): Four-way signal on post or bracket at each corner." (That is the Chicago loop system.) "Three, two or one-way signal posts, signal on post or bracket at each far corner. Three-way or two-way signal on post or bracket at near corner. Four-way signal suspended over the center of intersection. Four-way post on the safety island. Four or two-way signal on brackets on diagonal corner.

"The use of four-way signals on posts and safety island is limited in application to streets wide enough and with sufficient density of vehicle traffic to warrant such islands.

"The use of post signals at the centers of the intersections is not recommended, because they form unnecessary and dangerous obstructions."

Yesterday in the Signal Section there was considerable discussion on the proposition of having these signals which are located on the right of traffic duplicated; that is, the lights put back to back, so that a driver approaching will have his flashing light signal on the right before he gets to the crossing, and he will have a flashing light signal on the left, beyond the crossing.

If you will observe the traffic here in Chicago, you will note that the vehicles do not go clear up to the signal on the far side of the crossing before they stop; they stop short of the crossing. Railroad men generally have always felt that an engineman had a right to go all the way up to the signal. The signals were located at the danger point. The highway traffic control is different, and the drivers do not go clear up to the signal.

That is a new thought. Mr. Higgins, one of the Public Service Commissioners of Connecticut, has asked the New Haven to put in a couple of these signals, and they have done it, and it is being thought of very favorably.

I should like to have that reference to the center location eliminated for this year anyway, because I believe that in the course of another year or two we will have to double the signals up, and the driver will get an indication from the signal on the right, the near side, and the signal on the left, the far side. It would eliminate the objection of putting the signals in the center of the highway and also will give him the visibility which is desired.

Mr. Robert H. Ford:—I hope the Committee will not yield to this. I think, with all due regard to our last speaker, that I am as familiar with the Chicago situation as anybody else. The Rock Island has these signals placed exactly in conformity with the recommendations made by this Committee, and I can assure the last speaker that they are meeting with the utmost favor by the city of Chicago. They have proven to be safe and one of the best means of regulating traffic that we have in any of our large cities. We have this type of signals installed on our suburban lines, in one case on one of the heaviest traffic streets in Chicago, where two railroads are using a double-track line, where there is a train every forty minutes during the day, and during the peak hours a train running every eight or nine minutes, and we have no trouble whatever. Not only that, but it meets with the approval of not only the city but with the community in which the service is given.

This same character of service has been extended and has been watched not only by the Rock Island but other railroads interested, and I want to say to the convention that the recommendations of the Committee are sound and should stand.

As to what may happen in the future, I do not know, but I hope that the Committee will not alter their recommendations in this respect. I want to support them in their conclusions, because they are sound and practical.

Mr. Bernard Blum:—Mr. Chairman, I may say that this subject that is now under discussion was quite fully considered at our last general meeting of the entire Committee, and the conclusions as shown in the Bulletin met the general views of the entire Committee, and therefore I cannot withdraw the recommendations.

Personally, I am strongly in favor of the center of the road, although recognizing what Mr. Rudd has said about the recommendations of the Street Traffic Committee.

On the Northern Pacific we have a large number of the center of the road installations and our results as compared with the side of the road installations have been most satisfactory. For that reason I, personally, am in favor of the recommendations as presented.

Mr. A. H. Rudd:—The elimination of these words will not weaken this very much. The signals can still be put in the center of the road if the people want them there. The objectionable feature is that this report says they shall be placed there.

Mr. Bernard Blum:—Under certain conditions.

Mr. A. H. Rudd:—And they will not be because there are some states that will not permit the obstructions in centers of highways in cities.

If you want to get a standard, let's have one that can be made workable.

Past-President J. L. Campbell:—Is there any further discussion on this motion? If not, the motion is on the adoption of recommendation No. 3 at the bottom of page 496 as it stands.

(The motion was put to vote and carried.)

Chairman Frank Ringer:—Subject No. 5 is printed on page 503 of this Bulletin, "Continue the Study and Report on the Economic Aspects of Grade Crossing Protection in Lieu of Grade Crossing Separation." The Committee is making a progress report which will be read by Mr. A. H. Utter.

Mr. A. H. Utter (Chicago, Burlington & Quincy):—This report is made as a progress report to be received as information. A tabulation has been prepared and from that I will read the first, the sixth and the seventh columns: Type of protection, total annual cost, and annual cost capitalized.

Type of Protection	*Total Annual Cost*	*Annual Cost Capitalized*
Watchmen	$2869.03	$52,000
Gates	3251.35	59,000
Flashlights	454.66	8,300
Wigwags	442.58	8,000
Special Fixed Signs	12.68	250

Mr. President, I move the adoption of this as a progress report to be received as information, and that the study of the subject be continued.

Past-President J. L. Campbell:—If there is no discussion and no objection, it will be so received.

Chairman Frank Ringer:—We have a progress report also on Subject No. 6 printed on page 503, on the Use of Center Columns for Highway Grade Separations. Mr. Brennan, Chairman of the Sub-Committee, is not present. I will ask Mr. Palmer to report that subject.

Mr. G. P. Palmer (Baltimore & Ohio Chicago Terminal):—This is merely a progress report. The Committee sent out a circular to all the state highway authorities and all cities of 200,000 population or more asking for information regarding laws, ordinances, and other requirements governing the use of center columns in the highway at grade separations. To date we have received only a portion of the replies, and for that reason we are unable to make a report at this time. We recommend that the subject be continued for next year.

Past-President J. L. Campbell:—This report is received as information.

Chairman Frank Ringer:—Subject 5, Evolve a Formula which will Develop and Evaluate the Relative Benefits to the Public and Railways from: (a) Grade Crossing Protection; (b) Elimination of Grade Crossings; (c) Reduction of Traffic on Highway Grade Crossings. This is printed in the Bulletin beginning on page 504. I will ask Prof. R. B. Kittredge, Chairman of the Sub-Committee, to present this report.

Prof. R. B. Kittredge (State University of Iowa):—Brief discussions covering each of the three phases of the assignment are printed on pages 504 to 506 of Bulletin 312. The conclusions of the Committee are printed on pages 506 and 507, beginning at the bottom of page 506. The Committee is recommending the adoption of these conclusions and it is suggested that they should be read:

"1. In determination of the relative benefits to the public and railroads from (a) protection of highway grade crossings, (b) elimination of highway grade crossings and (c) reduction of traffic on highway grade crossings, consideration should be given to the following general principles:

"(a) Creation of new grade crossings should be avoided.

"(b) In the construction and improvement of highways and railroads, provision should be made for the elimination of existing highway grade crossings, including crossings of local roads where the road traffic can be diverted to the main highways.

"(c) Plans and agreements for highway crossing separations should provide for the abandonment and closing of the existing grade crossings carrying the same highway traffic.

"(d) Where the expense of grade crossing elimination or separation is not justified, protection should be provided. The character of protection should depend upon local conditions and the character and volume of traffic.

"(e) Increasing need for grade crossing protection is brought about principally by change in character and increase in volume of highway traffic. The benefit from such protection will accrue in greater proportion to users of the highway and the cost should be shared accordingly by state and municipal authorities.

"(f) The elimination or protection of highway grade crossings is of such importance, and involves the public safety to such an extent, that primary consideration should be given to such improvements in the allocation of capital by the railroads for safety measures designed to protect the public, and also in the allocation of funds made available by the Federal aid act and other legislation for highway improvements.

"(g) The order in which grade crossing elimination projects should be undertaken depends upon many varying factors, and should be fixed by a study of the local conditions at each crossing, care being taken to see that the greatest safety and expedition in the movement of traffic are secured for the money expended. Primary consideration should be given to the elimination of grade crossings at which extra hazard exists by reason of traffic and physical conditions.

"2. The relative benefits to the public and railroads from grade crossing protection, elimination, or reduction of traffic, cannot be evaluated by a formula, but must be arrived at in the light of reasoned judgment, having in view all the conditions and factors affecting the particular crossing. Among the elements to be considered are:

"(a) Physical Conditions:
1. Alinement.
2. Grades.
3. Visibility.
4. Drainage.
5. Character and cost of highway and railroad construction.

"(b) Railroad traffic:
1. Number and speed of trains.

"(c) Highway traffic:
  1. Number of automobiles.
  2. Number of trucks.
  3. Number of horse drawn vehicles.
  4. Relative proportion of local and through highway traffic.

"(d) Federal and state laws and regulations.

"3. The Committee desires to emphasize the necessity for sincere co-operation between railway and highway officials in the consideration of grade crossing problems."

I move the adoption of Conclusions 1 to 3, inclusive, to be printed in the Manual.

Mr. Robert H. Ford:—I think the conclusions are admirable, at least down as far as 2, but I can not go along with the Committee on the question of their interpretation of what the word "formula" means. They state: "The relative benefits to the public and railroads from grade crossing protection, elimination, or reduction of traffic, cannot be evaluated by a formula." They may be right or wrong, depending upon how the word "formula" is applied.

A formula is a fixed rule or exact statement, and the purpose of the formula is to carry out very largely what the Committee seems to be endeavoring to do themselves, from the question of arbitrary apportionment of cost, which is unsound and unscientific. The question of benefits is a fundamental principle of the allocation of cost. Now to arrive at what those benefits are, there must be some formula.

I think the Committee must have in mind a mathematical formula. If they have, I agree with them, but I do not think that was the intention of the assignment. It was to use it in the sense that I have described; that is to say, assuming that I am correct, that the allocation of cost is predicated upon the benefits derived (and I do not see how that is even debatable), the first thing for this Committee to do, I should think, is to set about some way of setting up how those benefits shall be reached. To do that, they have to have a formula, an exact statement.

When the Committee proceeds down here a little further and sets up those which they have done in very admirable shape, they go just the reverse of what they said. I would not object to it the way they have it, only they put in those words and then they proceed to do it. I wish that the Committee would strike out those words, because they have gone to work and done as they were told to do if they leave those words out, and that is this: Their instructions say: "to evolve a formula." Why, they have done it under (2). Then they go to work, as I said before, and say they have not done it by including the words "cannot be evaluated by a formula." I hope they will strike out those words. So much for that.

Under the text (and I am not quite sure that this is the proper place to allude to it) because I believe the discussion relates solely on the conclusions, and if they do I will reserve the remarks I have to some words of the text on page 504.

Past-President J. L. Campbell:—We had better confine ourselves to striking out these words.

Mr. Robert H. Ford:—I will ask the Committee if they will not delete the words "cannot be evaluated by a formula." They may have to change the wording a little after that. If they leave that out; I think they have done exactly what the Board asked them to do and they have done it in pretty good shape.

Chairman Frank Ringer:—Mr. President, this seems to turn on the meaning of the words, "a formula for evaluating benefits."

The Committee, as Mr. Ford has surmised, has understood that to mean a mathematical formula. The word "evaluate" means money, and it is the understanding of the Committee (this subject was discussed at great length at various times) that the subject means to devise a mathematical formula which would evaluate, in money, the benefits. The Committee does not believe it can be done, and perhaps Mr. Ford's views will be covered in the recommendations of the Committee for next year's work on that subject.

I might read that recommendation which is "to continue the study and report on a method for developing and evaluating." The Committee has in mind proceeding along exactly the line that Mr. Ford is suggesting, but it is the view of the Committee that a formula for evaluating in money the relative benefits to the public and railroads in grade crossing separations is a very difficult thing, to say the least. We do not think it can be done.

Mr. Robert H. Ford:—I am with the Committee on that were it not for the fact that the motion is to print this in the Manual, and I constitutionally object to anything going into the Manual that makes us look absurd the next year. I am very much in sympathy with the conclusions that they have drawn under Section 1.

Past-President J. L. Campbell:—Mr. Ford, the Committee says that it has no objections now to the exclusion of these words. Is there any further discussion?

Mr. V. R. Walling (Chicago & Western Indiana):—Under Item (c) they have enumerated automobiles, trucks, horse-drawn vehicles, and so forth. I wonder if it might not be well to include in there, "pedestrians."

Now, that may seem a little farfetched, and would, of course, under conditions of highway crossings out in the country, be farfetched.

Past-President J. L. Campbell:—The Committee says it will accept your suggestion. Is there any further discussion?

Mr. J. A. Peabody (Chicago & Northwestern):—In considering pedestrians, I think it would be well to separate school children from grown people. In taking care of this subject, I run into that item constantly, and I find now we have to get a record separately of the two items.

Chairman Frank Ringer:—I believe the suggestion in one of the other paragraphs there for considering the local conditions would naturally cover that feature.

Mr. J. A. Peabody:—That may be true, but would the report come into the general office for consideration unless you have that given out as instructions to your local officials? They will overlook it and the general office in considering it may overlook it, and very often, also, not be aware of what the tendency is. A schoolhouse may be put up without your knowledge somewhere in the vicinity, and change the conditions.

Chairman Frank Ringer:—I would see no objection to a word to divide the pedestrian traffic. However, these are general principles, and the manner in which the report comes in would include all pedestrians.

Past-President J. L. Campbell:—Is there any further discussion on the motion to adopt the recommendations of the Committee beginning at the bottom of page 506 and covering page 507, as they have been amended? If not, and this is for inclusion in the Manual, all in favor of the motion will say "aye"; contrary "no." The motion is carried.

Mr. Robert H. Ford:—If I may, I should like to call the Committee's attention to a rather surprising statement on page 504, in the first paragraph. It reads: "The principal benefit from grade-crossing protection is the reduction in the number of crossing accidents."

I want to take straight issue with the Committee on that statement because it is not so. The principal benefit is speeding up highway traffic or the convenience to the highway user against highway accidents. I want to say right here that the time has gone by for considering grade crossings from a purely accident preventive standpoint. Accident prevention is, of course, important but its work is largely educational, and which, by the way, should not be left entirely to the railroads to undertake.

Consistent and persistent education of the public aided by suitable legislation will operate to secure a great reduction by proper preventive and corrective methods. But however laudable its purpose in accomplishing this lighting effect for necessity in the speeding up of traffic over highways, it is of special value and importance to the public.

The point I want to make is this: There seems to be an impression among state and Federal authorities that the reason grade separation is necessary and why it should be paid for by the railroads is on account of grade-crossing accidents. The result is that a very large per cent is settled on the railroads for this reason. Fundamentally that is incorrect, as I have stated here. The time and conditions have changed and it is not the accidents, because accidents can be prevented and taken care of by proper educational methods and by the use of automatic protection.

In most cases where crossing separation is made, it is for the benefit of speeding up traffic for the convenience and necessity of the highway user. It is true, of course, that the railroads get a benefit from it. But, as I said a few moments ago, and the Committee apparently are in accord with that idea, the benefit can be allocated in some manner and termed in some means whereby we can get away from this question of arbitrary adjustment.

The time has gone by when we should say an arbitrary 50 per cent division of cost merely because each party is equally benefited. They would be equally benefited if the situation was equal, but it is not equal. I hope the Committee (I will not press this because I am satisfied that the Committee recognizes the facts) will correct those paragraphs so as to state the situation correctly and make it consistent with what they have said on the following pages.

Mr. E. R. Lewis (Michigan Central):—I agree with the last speaker. The pressure that is being brought to bear on the railroads today to separate grades is, first and foremost, congestion of traffic on the streets. As Mr. Ford has said, the day has gone by when the accident takes first place in consideration. Furthermore, the day has almost arrived when the grade crossing of the railroad is of secondary importance in grade separation. We are approaching the time of traffic saturation on the streets, and we are approaching the day when the problem of greatest importance in grade separation is highway from highway.

Chairman Frank Ringer:—The Committee discussed at length the point raised by Mr. Ford. Some difference of opinion developed as to the extent to which any crossing protection would speed up the highway traffic. I feel that Mr. Ford's remarks would apply more to grade separation than to grade crossing protection. However, this matter is for information, not for inclusion in the Manual. The Committee sees no objection to changing the first sentence to include both benefits from the reduction in the number of crossing accidents and also in the expediting of highway traffic.

Past-President J. L. Campbell:—The text of the report will be changed accordingly.

This completes the report of the Committee on Grade Crossings and we now excuse it with the thanks of the convention for its excellent work. (Applause.)

DISCUSSION ON TRACK

(For Report, see pp. 893-951)

(Vice-President G. D. Brooke in the Chair.)

Chairman J. V. Neubert (New York Central):—We will open our subject on page 898, Appendix B: "(2) Make critical review of the material now appearing in publications of the Association relating to curve elevation; ascertain existing views and practices of the railways; and recommend such changes as are found necessary." This is to be presented by Mr. C. W. Breed, Chairman of the Sub-Committee.

Mr. C. W. Breed (Chicago, Burlington & Quincy):—The report, as the subject indicates, is divided into three sections; that part in reference to review of the material now appearing in the publications relative to curve elevation, though brief, covers a detailed study of all material on this subject from the report in the Proceedings of the first convention in 1900 to the last revision in the Proceedings of 1915. The result is shown in the first section of the report.

The second part, existing views and practices of railways, is shown on pages 898 to 918, inclusive. Attention is called to a printer's error on page 912. The heading "New York Central, East and West, J. V. Neubert, Chief Engineer Maintenance of Way," should be dropped down to the middle of the page immediately preceding the line "We use formula

$$E = \frac{V^2 \times G}{32 - 2 \times R}."$$

The table is part of the Nashville, Chattanooga & St. Louis report, shown on previous page. Another slight error appears on the table on this page under the heading of "Degree of Curve." The figure in the second line should be 2 instead of 22.

The letters in this part of the report indicate conclusively that there has been established on practically all railways in this country the practice of fixing a speed, for which to elevate individual curves relatively less than that shown in the elevation table in the 1921 Manual for equilibrium speed, depending on the character of the traffic for which to provide comfort and safety and the location of curve as to grade, etc.

We therefore recommend the following changes in the Manual, occurring on page 895: The first change recommended is the specification for *S* in the first formula on page 184 of the 1921 Manual which now reads: "*S* = velocity in miles per hour, will give essentially correct theoretical elevation for the outer rail of curves and is recommended for ordinary practice." We wish to have it read: "*S* = Speed in miles per hour, will give essentially correct theoretical elevations for the outer rail of curves, in which the resultant of forces passes practically through the center line of track."

I move the Manual be changed as recommended.

Mr. B. R. Leffler (New York Central) :—In looking through the report I notice that there is considerable difference of viewpoint as shown in the various tables by the different roads, and also that some of the roads use the present A.R.E.A. table. It seems to me that this question of curve elevation is one so dependent on conditions of traffic, conditions of the rolling equipment, that it is unwise to give a table or a formula in the Manual.

I think it would be much more reasonable to cut out the table from the Manual entirely, and cut out any reference to a mathematical formula, naming instead a few leading principles that should govern rail elevation. By having a formula or a table of precise calculations, a false aspect is given to the matter, and consequently, use is made by various parties in a way that is detrimental to good railroad practice.

I have come to the conclusion that this is a matter that cannot be formulated on precise mathematical lines. I favor and suggest that all reference to any table or mathematical formula be eliminated from the Manual entirely.

Mr. C. W. Breed:—The formula gives the equilibrium speeds for elevating. It is simply a guide and should be so used.

Vice-President G. D. Brooke:—Is there any further discussion? If not, the recommendation of the Committee will be voted upon.

(The motion was put to a vote and carried.)

Mr. C. W. Breed:—Fourth paragraph on page 184 of the Manual now reads: "In general, in determining speed, consideration should be given to the traffic and the elevation fixed to give the greatest degree of economy in train operation."

The proposed recommended change is: "In general, in determining speed for which a curve shall be elevated, it is necessary to consider traffic which includes moderately slow freight and relatively fast passenger trains.

To secure economy in the operation of freight trains and comfort for passenger traffic, the selection of a speed in varying degrees less than the speed of the passenger trains over that particular curve is recommended."

I move the change be adopted.

Vice-President G. D. Brooke:—You have heard the recommendation. Is there any discussion?

(The motion was put to a vote and carried.)

Mr. C. W. Breed:—We wish to add the following note to page 184 of the Manual: "There will be found on page 916, Volume 30 of the 1929 Proceedings, a comparison in tabular form of curve elevations for equilibrium speed with comfortable, safe and theoretical overturning speeds."

I move the addition.

Vice-President G. D. Brooke:—The adoption of that recommendation has been moved and seconded. Is there any discussion?

(The motion was put to a vote and carried.)

Chairman J. V. Neubert:—We will next take up Appendix C on page 919, Detailed Plans of Switches, Frogs, Crossings, and Slip Switches. In the absence of Mr. C. R. Harding, it will be handled by Mr. Wakefield.

Mr. C. H. Wakefield (Southern Pacific):—Each year for several years this Committee has presented a number of plans for adoption, and as information, covering details and specifications for track work coming under this heading. With a view toward making this series of plans more complete, the Committee presents further plans this year, these plans having been prepared in collaboration with the Standardization Committee on the Manganese Track Society.

Before taking up the plans under Item I, Frog Lengths for Heavy Rail for Uniform Tie Spacing, I should like to direct your attention to plans 271 to 279, inclusive, following page 920 of the Bulletin.

The first note on these plans reads as follows: "Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝ inches but not exceeding 9$\frac{13}{16}$ inches)."

The Committee desires to amend this note on each of these plans by making an addition. The note will then read as follows: "Frogs on this plan designed for heavy rails (combined width of head and base more than 8⅝ inches but not exceeding 9$\frac{13}{16}$ inches); also recommended for other heavy rails 6½ inches high and over."

That last phrase is added in order to take care of such sections as the 130-lb. P.S. section rail.

Returning again to page 919 of the Bulletin under Item I, the Committee offers for adoption as recommended practice, and to be printed in the Manual plans 273 to 279, inclusive, covering No. 6 to No. 12 rail bound manganese steel, bolted rigid, spring rail and solid manganese steel frogs.

I move these plans be so adopted.

Vice-President G. D. Brooke:—It has been moved and seconded that these plans be adopted as standard practice and printed in the Manual. Is there any discussion?

(The motion was put to a vote and carried.)

Mr. C. H. Wakefield:—As companion plans to plans covering No. 4 and No. 5 frogs for lighter rails, the Committee offers for information plans 271 and 272 of No. 4 and No. 5 rail bound manganese steel, bolted rigid, and solid manganese steel frogs. These plans are offered for information only.

Vice-President G. D. Brooke:—If there is no discussion, we will proceed.

Mr. C. H. Wakefield:—Next is Item II, Flange or Self-Guarded Frogs. "Last year plan No. 343, dated November, 1927, of A.R.E.A. No. 8 self-guarded bolted rigid frog, was presented as information to invite criticism." This year the Committee presents this plan, as well as additional plans 341, 342 and 344, No. 6, No. 7 and No. 10 self-guarded bolted rigid frogs. These plans are offered for adoption as recommended practice, and to be printed in the Manual.

I move that they be so adopted.

Vice-President G. D. Brooke:—You have heard the motion. Is there any discussion?

Mr. J. L. Campbell (Northwestern Pacific):—I really intended to ask this question in connection with the first motion. It is this: Is this the first time these plans have been submitted on the floor of the convention?

Chairman J. V. Neubert:—No, sir. These plans have been submitted before the convention at least once, if not more times—in all respects.

Vice-President G. D. Brooke:—Any further questions or discussion?

(The motion was put to a vote and carried.)

Mr. C. H. Wakefield:—Next is Item III, One-Piece Guard Rails. "Plan No. 510 of A.R.E.A. manganese steel one-piece guard rail, 8 ft. 4½ in. length for installation on six ties, dated November, 1928, is presented as information to invite criticism."

Vice-President G. D. Brooke:—It will be so accepted.

Mr. C. H. Wakefield:—The next is Item IV, Adjustable Rail Braces. "The Committee offers for adoption as recommended practice, and to be printed in the Manual, written plan No. 240, dated November, 1928, of A.R.E.A. specifications for adjustable rail braces."

I move that this plan be so adopted.

Chairman J. V. Neubert:—I wish to advise that this is a written plan and has never been before the convention in this form. Reference has been given to it, but it has not been written out in this way before.

Vice-President G. D. Brooke:—Is there any discussion? That is upon the adoption for printing in the Manual Plan 240 on page 920 of the Bulletin. Those in favor of the motion will please say "aye"; contrary "no." It is carried.

Chairman J. V. Neubert:—I now wish to refer you to page 895, Appendix A, Revision of Manual. Mr. Breed forgot to mention on the top of that page: "The Committee recommends the following changes in the Manual and in adopted plans and specifications:

"Withdraw graphic chart shown on page 189 of 1921 Manual, entitled 'Speeds of trains on curves—overturning speeds—resultant through gage line—height of center of gravity 84 inches.'" I so move.

Vice-President G. D. Brooke:—Unless there is objection, that chart will be omitted.

Chairman J. V. Neubert:—On page 896, in regard to Plans 640 and so forth, self-guarded solid construction, we have had under consideration the taking care of the tie spacing, revising of the distance of Classes H and J. The Committee has had this under advisement, and we now submit plans 640, 643 and 670. I move their adoption.

Vice-President G. D. Brooke:—You have heard the motion. Is there any discussion? If not, those in favor will say "aye"; opposed, "no." It is carried.

Chairman J. V. Neubert:—We also have the following revision to the plans to make them consistent with later plans recommended. There are a number of these plans, and it is more or less editing, and this includes the plans as Mr. Wakefield has just referred to and as you have adopted. I recommend that these slight corrections be adopted as a group.

Vice-President G. D. Brooke:—Unless there is some objection, that will be done.

Chairman J. V. Neubert:—Revisions to specifications for switches, frogs, crossings, guard rails, the following is recommended, particularly in regard to Section 38, Proposed Form. "Fit of Bolts. Main bolts (also referred to on plans as 'through' or 'body' bolts) in bolted rigid frogs and bolted rail crossings shall have a tight fit in straight, true holes. Heads and nuts shall have a square bearing. Other bolts not requiring a tight fit, unless otherwise specified, shall have a clearance of not more than 1/16 in. in drilled or punched holes and not more than 1/8 in. in cored holes. Holes in solid manganese steel frogs and crossings to be 1/4 in. larger than bolt diameter as specified on plans. Threads must be U.S. standard, accurately cut within tolerance of the best practice for cut threads. Nuts must have a tight fit." This is changed in order to make them coincide with crossing frog plans which have already been adopted. I so move.

Vice-President G. D. Brooke:—You have heard the motion. Is there any discussion? If not, those in favor will say "aye"; opposed, "no." It is adopted.

Chairman J. V. Neubert:—We have here index sheets, pages 1, 2, 3, 4 and 5. These have been corrected from year to year in order to make them consistent with the correction plan. I move you these index sheets be adopted as revised.

Vice-President G. D. Brooke:—Unless there is objection these substitutions will be made.

Chairman J. V. Neubert:—I wish now to refer you to page 922, Appendix D. Mr. E. W. Caruthers is Chairman of this Committee.

We are working on additional plans which cover the scope of this Sub-Committee, and this Committee wishes to report progress. We will have some food for thought and plans to report next year.

Appendix E, you will find on page 922. Mr. O. F. Harting is Chairman of this Sub-Committee and will present this report.

Mr. O. F. Harting (Terminal Railroad Association of St. Louis):—This report of Sub-Committee 5 deals only with the arrangement of ties under railway crossings, as the first part of its assignment was acceptably completed last year. The four plans that form a part of this report immediately precede page 921.

While the possible angles of different railroad crossings are infinite in number, the Committee has designed only a few typical layouts for the arrangement of crossing ties, and believes that they will be helpful to the man in the field, regardless of what the angle of the crossing may be.

While there seems to be unanimity of opinion among railroad engineers that the diagonal method of arranging cross-ties is best for all angles up to 50 degrees, there is considerable difference of opinion about angles from 50 degrees to 90 degrees, for which reason the Committee has shown three alternate layouts for these angles. Which of these three layouts is best depends somewhat upon prevailing conditions.

I move that the following series of four plans be adopted as recommended practice and printed in the Manual:

Plan No. 719-A, Plan No. 719-B, Plan No. 719-C and Plan No. 719-D. I should like to add that the first three mentioned plans were accepted last year as information, and that the last mentioned plan is new. Also, that Plan No. 719-D supersedes Plans No. 720 and No. 720-A heretofore accepted as information.

Vice-President G. D. Brooke:—Is there any discussion on this motion?

(The motion was put to a vote and carried.)

Chairman J. V. Neubert:—For information this closes this subject.

Appendix F, page 924, Methods of Reducing Rail Wear on Curves with Particular Reference to Oiling the Rail or Wheel Flanges. Mr. C. M. McVay is Chairman of this Sub-Committee.

Mr. C. M. McVay (Nicholas, Fayette & Greenbrier):—This report is offered as information only; therefore it is not necessary to read it.

I might say that it was worked up by collaboration with the Sub-Committee of the Rail Committee and representatives, and about all that we have been able to find so far is the practice of applying oil to wheel flanges to reduce rail wear. This practice is comparatively recent. It was probably begun about four or five years ago and has not as yet become general on the different roads, but it has been gaining fast and many roads are now adopting the practice.

The Committee will continue to keep in touch with the various developments and make you an additional report next year of anything we may find tending to throw more light on the subject.

The practice was first tried by hand, and oil was applied by hand. After that some machines were developed and oil is now being applied on quite a number of roads in several different ways. We hope to have more information for you later, but this report, I think, covers the recent details of this practice and will inform you as to what is going on now.

Vice-President G. D. Brooke:—This will be received as information.

Chairman J. V. Neubert:—Appendix G, on page 928, Cause and Effect of Brine Drippings. Mr. Arn is Chairman of this Committee and will present this report.

Mr. W. G. Arn (Illinois Central):—Your Committee on Cause and Effect of Brine Drippings found that there was a similar Committee in the Mechanical Division, and it was therefore arranged to work with this Committee. A joint questionnaire was prepared and sent to all the railroads. The questions on the questionnaire are given on page 929 of the Bulletin. At the time the Bulletin went to press no information had been received in reply to this questionnaire. Since that time, however, many of the replies have been received, and a summary of the more important ones is given in the following information:

There is quite a difference in the percentage of this type of cars in which salt is used on the different railroads and in the percentage of salt used. The cases in which salt is used with ice on the lading in this type of car are so few as to be negligible. This type of refrigerator does not have brine retaining devices, and as they are now constructed, it is not practicable to equip them with brine retaining devices.

In answer to Question 2, with reference to the meat type of cars: Five of the roads report frankly that no attempt is made to keep the brine retaining apparatus in working condition; seventeen roads state that inspections are made, and on some of these roads the defects are reported to the owners, but the cars are allowed to go forward; twelve roads report that they make minor repairs, and one originating line reports that it returns to the owner cars on which defects are found in the brine retaining apparatus at point of origin. The cars found to be defective vary on different roads from 0 per cent to 61 per cent, and ten of the roads report finding leakages from other parts of the car than brine retaining devices.

Suggestions for improving conditions include the following: Closer inspection; maintaining retaining apparatus in better condition; install a better type of valve; improve the design of the brine retaining apparatus; arrange the drip on the fruit and vegetable cars to clear the track; use a mechanical or chemical refrigerant.

In answer to Question 3, the damage to exposed parts of the railroad is estimated on different roads as follows: Steel bridges: From 0 per cent to 60 per cent of service life; rail: From 0 per cent to 50 per cent of service life; tie plates and track fastenings: From 0 per cent to 75 per cent of service life; signal apparatus: From 0 per cent to 75 per cent of service life; car trucks: From 0 per cent to 50 per cent.

One railroad reported damage to concrete platform.

In answer to Question 4, an estimate of the money damage was furnished by a few roads. Those furnishing figures estimated the damage to bridges, track and signals at figures varying from nothing to $200 per mile, and from nothing to a total of $500,000 per system. One company estimates the damage to car trucks at $5 per car per year.

In answer to Question 5, the following are the most important suggestions for protecting against deterioration of track: Oil the track with Texaco No. 45 oil; oil track with ordinary crude oil; use copper bearing tie plates, spikes, and angle bars; paint track fastenings with No-ox-id.

For bridges: Paint the members exposed to brine drippings often enough to give them protection; use Armco brine troughs; cover steel bridge members with sheet lead and prepared roofing; use creosoted bearing blocks.

The various paint materials recommended are: No-ox-id paint; asphaltic paint; Texas No. 45 oil; crude oil; Toch's R.I.W. paint; bridge cement; Gilso cement.

For signals: Use copper weld bond wires; use galvanized and copper metals; paint exposed parts with one of the following: Texaco crater compound, No-ox-id paint, graphite paint, crude oil.

For car trucks: Paint car trucks with roof cement paint.

Amend 1922 Mechanical Division rules for testing under full head of water and stencil car with date of test.

In answer to Question 6, the following are the most important suggestions for eliminating deterioration: Improve the brine tanks and valves on meat cars to make them more effective; use copper bearing steel in bridge structures and in track material; put a concrete deck on steel bridges; use a refrigerant which does not drip a corrosive liquid; put brine retainers on fruit and vegetable cars; use only meat cars for shipments requiring salt; use larger brine tanks; use copper bearing steel for making the brine tanks.

The railroads handled 1,305,659 refrigerator cars in 1927.

The refrigerator cars handled in 1927 were 3.7 per cent of the total cars handled.

The proportion of refrigerator cars handled in 1927 was 0.1 per cent in excess of the proportion handled in each of the years 1924, 1925 and 1926. This subject is still under investigation and this is merely submitted as information.

Mr. W. H. Courtenay (Louisville & Nashville):—This matter has been before this Association for years and nothing has been done about it. I wish to bring before the Association the great importance of the matter. I think there are a number of roads here that have tried almost every conceivable rust preventative that has been suggested, proprietary or otherwise, and still there is nothing being done. There is no question but that the damage is enormous. It is utterly impracticable to determine the amount of damage as a result of this.

I think this Association should use every effort in its power to stop the shipment of brine over the railroads without satisfactory brine retainers from which the brine may be emptied at stated points. I think the Association should follow the matter up and not let it drop.

Vice-President G. D. Brooke:—This report is submitted as information. It will be so received and the Committee will continue the subject and continue its investigation with a view to a solution of it, if practicable. It will be so received.

Mr. W. H. Courtenay:—What I am anxious to get done is to not give further consideration to the matter but to take some action that will give some abatement to the use.

Chairman J. V. Neubert:—This Committee has not had this baby so long. We are working in harmony with the Mechanical Division of the A.R.A. It is dragging along and we should get some results.

Mr. W. H. Courtenay:—I brought this matter before this Association years ago.

Chairman J. V. Neubert:—We omitted, in the Bulletin, referring to a subject which we did not print: Continue study of corrosion of rail and fastenings in tunnels, collaborating with the Committee on Rail. We only have a progress report, as the first assignment was last year. We have a questionnaire out but very few replies are in now. We will make a report on it next year.

The next report is on page 930, Appendix H, Prepare Plans and Specifications for Track Tools, Mr. G. M. Strachan.

Mr. G. M. Strachan (Atchison, Topeka & Santa Fe):—This subject has been assigned by the Committee on Outline of Work to the Committee on Track with jurisdiction over the preparation of specifications and design of track tools of all description, collaborating with the Ballast Committee and other interested committees.

The Committee submits herewith plans and specifications for certain track tools as information, inviting criticism, and recommends that the subject be assigned for further study.

Vice-President G. D. Brooke:—It will be so received.

That completes the report of this Committee. As you see, it is a very large Committee, it has done a large amount of excellent work and has presented the Association with some excellent results. It is excused with the thanks of the Association. (Applause.)

DISCUSSION ON ELECTRICITY

(For Report, see pp. 411-485)

Chairman Sidney Withington (New York, New Haven & Hartford):—This, as I understand it, is now a meeting of the Electrical Section of the American Railway Association for the presentation of the report of the Committee on Electricity of the American Railway Engineering Association. We shall be as brief as we can in view of the lateness of the hour. First, I want to present a resolution on the death of our previous Chairman. This last year we suffered an irreparable loss in Mr. Katte's death, and we passed a resolution, which I shall now take the liberty of reading to you:

"The Electrical Section of the American Railway Association records with sorrow the death, on July 19, 1928, of Edwin Britton Katte, Chief Engineer Electric Traction, New York Central Lines, and Chairman of the Electrical Section.

"Mr. Katte was an active member of a number of technical societies and served with conspicuous ability as a Director of the American Railway Engineering Association for three years, as Chairman of its Committee on Electricity for eleven years, and as Chairman of the Electrical Section since its reorganization two years ago. Under his leadership the scope of activities of the Section has been materially broadened and the usefulness of its reports to railroads enhanced. His broad electrical experience and distinguished technical attainments, sound common sense, high integrity and lovable character not only made him a most capable leader and advisor in the activities of the Electrical Section, but endeared him to all of his associates.

"We extend our profound sympathy to his bereaved widow and members of his family, and direct that a copy of this resolution be conveyed to them; also to the American Railway Engineering Association and the American Railway Association."

The first committee report which we shall present is the study of the subject of Inductive Co-ordination Between Traction and Power Circuits. This is a very important subject, which has been under consideration for a number of years, and I presume those who are interested have read the present report, which is mainly a general exposition of the subject. It is recommended that this report be accepted as information, and that the subject be continued. Unless there is objection, we shall consider this satisfactory.

The next report is on the further study of water power developments which have recently taken place. I am going to ask the Chairman of that Committee, Mr. Needham, to present the report.

Mr. R. J. Needham (Canadian National) :—The activities of the Sub-Committee on Water Power have been outlined for the present year as follows:

1. Continue study of Tidal Water Development on Passamoquoddy Bay and St. Lawrence River when actual construction is in progress.

2. Report on Alabama Power Development on Tennessee River.

3. Present information as to extent that water power is used for railroad operation at the present time.

No actual construction work has been started on either the St. Lawrence River or the Passamoquoddy Bay projects.

It was not considered desirable for the Sub-Committee to visit the water power developments of the Tennessee River until such time as the political situation relating to them has been cleared up, and the developments are undertaken. The one important development on this river is the Muscle Shoals, and the status of this project is so involved in Federal politics that very little can at this time be said beyond what was contained in last year's report.

The Sub-Committee feels it might be well at this time to outline the Water Power policy of the United States, as it is embodied in the Federal Water Power Act of June 10, 1920.

A synopsis of this act is given on pages 424, 425 and 426.

Statement of electrified steam railroads, 1924, which was submitted with our report in 1925 covering electrification data, and the extent which water power is used on electrified steam railroads, has been brought up to date, that is, up through the year 1927, in accordance with statement which accompanies this report on page 430.

The Sectional Committee of the American Engineering Standards Committee on the Rating of Rivers, on which the Electrical Section of the

Mr. W. H. Courtenay:—I brought this matter before this Association years ago.

Chairman J. V. Neubert:—We omitted, in the Bulletin, referring to a subject which we did not print: Continue study of corrosion of rail and fastenings in tunnels, collaborating with the Committee on Rail. We only have a progress report, as the first assignment was last year. We have a questionnaire out but very few replies are in now. We will make a report on it next year.

The next report is on page 930, Appendix H, Prepare Plans and Specifications for Track Tools, Mr. G. M. Strachan.

Mr. G. M. Strachan (Atchison, Topeka & Santa Fe):—This subject has been assigned by the Committee on Outline of Work to the Committee on Track with jurisdiction over the preparation of specifications and design of track tools of all description, collaborating with the Ballast Committee and other interested committees.

The Committee submits herewith plans and specifications for certain track tools as information, inviting criticism, and recommends that the subject be assigned for further study.

Vice-President G. D. Brooke:—It will be so received.

That completes the report of this Committee. As you see, it is a very large Committee, it has done a large amount of excellent work and has presented the Association with some excellent results. It is excused with the thanks of the Association. (Applause.)

DISCUSSION ON ELECTRICITY

(For Report, see pp. 411-485)

Chairman Sidney Withington (New York, New Haven & Hartford):—This, as I understand it, is now a meeting of the Electrical Section of the American Railway Association for the presentation of the report of the Committee on Electricity of the American Railway Engineering Association. We shall be as brief as we can in view of the lateness of the hour. First, I want to present a resolution on the death of our previous Chairman. This last year we suffered an irreparable loss in Mr. Katte's death, and we passed a resolution, which I shall now take the liberty of reading to you:

"The Electrical Section of the American Railway Association records with sorrow the death, on July 19, 1928, of Edwin Britton Katte, Chief Engineer Electric Traction, New York Central Lines, and Chairman of the Electrical Section.

"Mr. Katte was an active member of a number of technical societies and served with conspicuous ability as a Director of the American Railway Engineering Association for three years, as Chairman of its Committee on Electricity for eleven years, and as Chairman of the Electrical Section since its reorganization two years ago. Under his leadership the scope of activities of the Section has been materially broadened and the usefulness of its reports to railroads enhanced. His broad electrical experience and distinguished technical attainments, sound common sense, high integrity and lovable character not only made him a most capable leader and advisor in the activities of the Electrical Section, but endeared him to all of his associates.

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The Sectional Committee of the American Engineering Standards Committee on the Rating of Rivers, on which the Electrical Section of the seem that the report of your Sub-Committee could well be referred to the Joint Committee on Electric Traction.

"However, there has been a great deal of excellent work done in preparation of this report and it is my suggestion that the report be published in the Proceedings of the A.R.E.A. in substantially the form in which you have prepared it, and let the Association at its next Annual Meeting decide on the disposition that should be made of it. This is advance information that will be useful to the engineers of railroad companies who are concerned with this particular problem. The ultimate disposition of this excellent report need not deter the Committee on Economics of Railway Location from submitting it to the Annual Convention."

This is a progress report of Committee 7 of the Electrical Section whose activity is dependent upon the work of Committee 2 of Committee XVI—Economics of Railway Location.

Chairman Sidney Withington:—Unless there is objection, we shall consider it is agreeable that the subject be continued.

The next report is the study of insulating tapes with special reference to cambric and paper tapes. Mr. Lebenbaum is Vice-Chairman of the Committee. I shall ask him to very briefly summarize the report.

Mr. Paul Lebenbaum (Southern Pacific):—The work assigned to this Sub-Committee was the study of insulating tapes with especial reference to varnished cambric and paper tapes.

With respect to varnished cambric tape, the Sub-Committee has received and examined samples of various thicknesses and type of manufacture. The Sub-Committee at this time can, therefore, only report progress.

In connection with paper tape, additional information is still necessary in order to prepare specification for the tape. Some attention has been given to the subject, but the work has not advanced sufficiently for an extended report.

It is recommended that the work on the preparation of these specifications be continued.

Chairman Sidney Withington:—Unless there is an objection, we shall assume that is satisfactory.

The next Committee report is that of the study of insulators, which is a continuing subject. I am going to ask Mr. Wright to present a brief summary of that report in the absence of the Chairman of the Committee.

Mr. G. I. Wright:—The two assignments to the Committee this year were: First, to revise and keep up to date the insulator specifications; second, to investigate the insulators made of boro-silicate glass.

The following action has been taken: "1. The Sub-Committee does not believe that a revision of the specification should be made at this time. Some changes in definitions have been proposed by the Insulator Committee of the American Institute of Electrical Engineers and have been approved by the Committee on Electricity. These changes will be included in a future revision of the specification.

"2. The Sub-Committee has investigated the use of insulators made of boro-silicate glass."

The Committee made an inspection trip to the factory which manufactures this type of insulators in this country, and the Committee is of the opinion that pin type insulators of proper design made of this material are suitable for transmission lines. It is recommended that this subject be continued.

Chairman Sidney Withington:—Unless there is an objection, we shall assume that is satisfactory.

The next Committee to report is that of Clearances for Third-Rail and Overhead Working Conductors. Mr. C. G. Winslow is Vice-Chairman of that Committee and I am going to ask him to present the report in very brief summary in the absence of the Committee Chairman.

Mr. C. G. Winslow (Michigan Central):—No new diagrams or tables as to clearances for third rail or overhead working conductors are submitted this year, as these data, which are submitted every two years to the Association, were reported upon as of November 1, 1927. The usual steps will be taken in 1929 to review these data and to bring them before the Association.

This Committee is also working with the Special Committee on Clearances and hopes next year to have something to say on the subject of safe clearance for overhead conductors to ground.

It is recommended that this subject be continued.

Chairman Sidney Withington:—We shall assume that is satisfactory unless there is objection.

The next subject is the continuation of the study of Protection of Oil Sidings from Danger Due to Stray Currents. I am going to ask Mr. Winship, of the Boston & Maine, who is Chairman of that Committee, to briefly summarize the report.

Mr. L. C. Winship (Boston & Maine):—The Sub-Committee has carefully considered the revision of the Rules for Protection of Oil Sidings from Danger Due to Stray Currents, adopted in 1924 by the American Railway Engineering Association.

From the information which has been gathered during the year it appears advisable to present a new draft of these Rules for consideration in 1929, this draft to include Rules for Protection from Danger Due to Static Electricity.

It is recommended that this subject be continued.

Chairman Sidney Withington:—Unless there are comments we will assume that is agreeable.

The next subject is the study of track and third-rail bonds. This is an exceedingly important subject which has been the subject of a great deal of study during the past year. I am going to ask Mr. Hagan, who is Vice-Chairman of the Committee, to very briefly summarize the report. The time is getting very short so the summary will be necessarily very brief.

Mr. J. S. Hagan (Central Railroad of New Jersey):—The assignment of Committee XII, Specifications for Track and Third Rail Bonds, was divided into five sub-headings: Study of Details of Bond Design with a

View to Developing Specifications Covering the Different Classes of Bonds. This was found to be a very broad assignment because of the large number of types of rail joints, and the Committee gathered a great deal of information on the various types of joints and the types of bonds which had been applied to those joints, but it was unable to arrive at a definite conclusion with respect to specifications.

It is recommended that this part of the subject be continued next year.

The second assignment, Collection of Information as to Methods and Extent of Practice in Reapplying Bonds, is covered in the report on pages 444 and 445. This is the returns from questionnaires which were sent out and concludes that assignment.

The fourth subject, Study of Contact Areas and Resistances for Different Types of Bonds. Information is given covering the mechanically applied bonds, but research was necessary by the manufacturers in connection with welded types of bonds. The manufacturers are submitting information for the report for next year, and it is recommended that this subject be continued.

The fifth subject, Compiling Information Concerning Rail Joint Clearances and Its Effect on Rail Bond Design, is tied in with the first assignment of the Committee, that of preparation of specifications. The result of what I have said regarding the first assignment also applies to the fifth assignment. It is recommended that this report be accepted as progress and that the subject be continued with reference to: First, study of details of bond design with a view to developing specifications covering the different classes of bonds; and second, collection of data on compositions used on rail joints to replace bonds; and third, study of contact areas and resistances to different types of bonds.

Chairman Sidney Withington:—Unless there is an objection we will assume that is satisfactory. The next subject is the revision of incandescent lamp schedule and continuation of the study of floodlighting for classification yards and for other railroad purposes. This is an exceedingly important subject. I shall ask Mr. Winship to very briefly review the work of that Committee. It will, unfortunately, be necessary to be very brief.

Mr. L. C. Winship:—(1) Revision of the incandescent lamp schedules to bring them up to date and to include a schedule of miniature lamps recommended for railroad use. (2) Preparation of specification for incandescent lamps. (3) Continuation of the study of floodlighting for classification yards and other railroad purposes.

The recommendations are: (1) That the schedules of incandescent lamps as presented in this report be accepted as recommended practice and the subject continued. It is recommended that these schedules be placed in the Manual. (2) That the subject of the preparation of a general specification for incandescent lamps be continued. (3) That the report on railroad floodlighting be accepted as information and the subject continued.

Chairman Sidney Withington:—We will assume that that is satisfactory unless there are objections.

The next subject is the continuation of studies in connection with design of indoor and outdoor substations. That is one of the most voluminous and valuable reports which the Committee presents. I am going to ask Mr. Vandersluis to very briefly summarize the study.

Mr. W. M. Vandersluis (Illinois Central):—The program of this Committee is found on page 459, Bulletin 312. It is the same program as was given last year. The items covered are shown on the report on pages 466 to 481. Your particular attention is called to the report on Item No. 2, "Determine applicability of various methods of controlling substations and equipment as follows: (a) Manual control; (b) Remote control; (c) Supervisory control; (d) Semi-automatic control; (e) Automatic control; (f) Substation battery and charging equipment."

Under the heading "Study and report on present development and major considerations in selection of certain types of apparatus," report is given on mercury arc rectifiers, protective devices, including relays and lightning arresters, and on meters and meter transformers.

Under "Miscellaneous important questions" are results of inquiries received covering tabulation of minimum clearances between conductors and conductor to ground for various voltages, both indoor and outdoor; also tabulation of adequate insulation, phase to phase and phase to ground, for various voltages, both indoor and outdoor.

Then there is the study and report on permanent and emergency grounding protection, and the study on the possibilities of unit type of construction as applied to substations.

It is recommended that this report be accepted as information.

Chairman Sidney Withington:—The reports of this Committee on Substations extending over the last three or four years represent what might be almost termed a textbook on the subject. They are, I think, of considerable value.

The next subject on our list is the subject of High Tension Cable. There are no new data on that subject this year, but the Committee has been studying the question and recommends that it be continued. Unless there is objection or comment, we shall assume that that is satisfactory.

The next subject is the very important one of corrosion-resisting materials as applied to railroad electrical construction.

I shall ask Mr. R. P. Winton, of the Norfolk & Western, to very briefly present that report. Mr. Winton is the Chairman of that Sub-Committee.

Mr. R. P. Winton (Norfolk & Western):—The first subject considered this year was study of use of copper bearing structural steels for catenary bridges and transmission towers. There has been a lot of good work done on the use of copper bearing steel in freight cars, and some work has been done on the use of copper bearing steel for structural purposes, but so far as we were able to find out, there is no work published on structural steels exposed to gases of steam locomotives, which is the subject we are particularly interested in, because the steel used in catenary bridges and transmission towers is exposed to those gases from steam locomotives. We were not able to find any information of value on that subject.

The second subject was the study of corrosion-resisting materials suitable for catenary messenger or catenary hardware, suitable for line construction. A questionnaire was sent out to the various railroads but we were unable to find anything on the probable life of the various materials. In most cases the materials have not been used long enough to predict their life. We were, however, able to get considerable information in regard to physical properties of various materials claimed by the manufacturers to be corrosion-resisting. This information is included in this year's report, but we are not able to offer any opinion as to the probable life of these various materials.

The Committee recommends that this report be accepted as information and the subject continued.

Chairman Sidney Withington:—That ends our technical report.

I shall ask Mr. Vandersluis, Chairman of the Committee on the Revision of Manual, to very briefly report on that subject.

Mr. W. M. Vandersluis:—Sub-Committee 13 has recommended that a new Incandescent Lamp schedule be placed in the Manual. Last year it was found that the 1926 schedule in the Manual was obsolete, and a motion was passed removing it. Now it is in order to place in the Manual the revised Incandescent Lamp schedule as shown on pages 448, 449, 450 and 451, Bulletin 312. It is so recommended and a motion is desired.

Chairman Sidney Withington:—Do I hear a motion to that effect?

(Upon motion regularly made and seconded, it was voted to place in the Manual the revised Incandescent Lamp schedule as shown on pages 448, 449, 450 and 451 of Bulletin 312.)

Chairman Sidney Withington:—That completes our report with the exception of Recommendations for Future Work as shown on page 413. I shall not read those because they have been published already.

In addition to the recommendations printed here, it is probable that the Committee this year will study the question of power in its various phases, power production, and perhaps contracts. We haven't as yet formulated a definite program on the subjects involved but are collaborating with other committees interested.

We have also undertaken collaboration with technical committees of other organizations, as noted in the outline, notably the American Railway Association, the Association of Railway Electrical Engineers, the National Electrical Safety Code, the National Electric Light Association, and there is no doubt that thereby much duplication of effort and lost motion is going to be avoided.

That completes our report.

Vice-President G. D. Brooke:—It is appropriate at this time that the American Railway Engineering Association endorse and approve the report which has just been made by the Committee on Electricity. I will entertain a motion to that effect.

Mr. Louis Yager (Northern Pacific):—I so move you, Mr. Chairman.

(The motion was regularly seconded, was put to a vote and carried.)

Vice-President G. D. Brooke:—Thank you, Mr. Withington. Your Committee is excused with the thanks of this Association. (Applause.)

DISCUSSION ON SIGNALS AND INTERLOCKING

(For Report, see pp. 509-548)

(Vice-President G. D. Brooke in the Chair.)

Chairman W. M. Post (Pennsylvania):—The report of this Committee is found on page 509. We have no report on assignment No. 1. No revisions are recommended.

Assignment 2, Report on developments of automatic train control, collaborating with Train Control Committee. This report will be found on page 511, Appendix A.

Since this report was submitted the Interstate Commerce Commission has reported on the hearings which were held last spring. No doubt you have read the report of the Interstate Commerce Commission. It was clearly brought out, I think, that the Interstate Commerce Commission does not intend to let down in any way on advancing safety on the railroads. Apparently they will not be so insistent upon only one form of safety; namely, automatic train stops. Other methods will be permitted. The Interstate Commerce Commission has not issued any orders recently for additional automatic train stop installation. Apparently they will watch the railroads and see what they do to advance the safety on the roads.

At a meeting of the Signal Section yesterday, Mr. Borland addressed us, and if you have not already done so, I would advise you to read his brief remarks, which appeared in Tuesday's issue of the *Railway Age*. I will read one or two paragraphs, indicating better than I can say the position of the Interstate Commerce Commission. Mr. Borland is the Director of the Bureau of Safety of the Interstate Commerce Commission. He said:

"We are not going to be so insistent about train control as the only thing that needs to be done, but in places where the evidence is positive that train control is needed, the Commission is going to require it; while in places where other methods would accomplish the results as effectively as train control, the Commission is willing to permit the roads to use those methods.

"Do not get the impression that the Commission has changed its policy in any respect or that it is going to let down on the question of safety to the public, because that is the duty imposed on it by law. The Commission is going to perform its duty just as effectively as it can."

It may be of interest to know that the Pennsylvania Railroad is making an installation of cab signals on its New York Division between Philadelphia and Manhattan Transfer without automatic train stops. We believe that provides added safety and will be sufficient. The Pennsylvania Railroad has also authorized installation of automatic cab signals on its line between Philadelphia and Washington.

We have shown in this report the exceptions and requirements on several inspections made by the Interstate Commerce Commission inspectors. I shall not do any more than call your attention to them. They are given so that they can be incorporated in our literature and are available to anyone who is interested.

We also have a report on Development of Highway Crossing Protection, on page 524. The closing paragraph states that Committee X will present a verbal report at the Annual Meeting in March. I will ask Mr. Rudd to make a statement at this time.

Mr. A. H. Rudd (Pennsylvania) :—Probably the most important development in grade-crossing protection has been the completion of the report of the American Engineering Council on the traffic signals.

The National Conference on Street and Highway Safety, of which Hon. Herbert Hoover was Chairman, has practically completed its labors and Mr. Hoover has been assigned to another duty.

The associations co-operating in this conference were ten in number, the American Railway Association being one of them. This book is issued as a report of the Committee of the American Engineering Council on Street Traffic Signs, Signals and Markings, 1929, and may be obtained from the Association at twenty-five cents a copy, address 26 Jackson Place, N. W., Washington, D. C.

The municipal ordinance in its explanatory note requests that municipalities consult this book of recommendations of the American Engineering Council before deciding on what signals they will use.

We have a section in which the display of unauthorized signs is forbidden; the marring of signs forbidden. There are paragraphs requiring the vehicles to stop at railroad crossing signals. They have adopted the approach sign, as passed here today, yellow background and black letters, identical with the A.R.E.A. standard, and provide for a crossing sign. "A railroad crossing sign shall be made of two arms mounted across each other in inclined positions to form a crossbuck." That can be any angle we want. The sign is to be white with black letters. They adopted the A.R.E.A. Standard Highway Crossing Signal without change.

The octagonal stop sign recommended is yellow background with red letters.

I think that is about all there is to say except that they have something to say (that I read this afternoon) about the location of signals. They have standardized on the crossing gate, taking the A.R.E.A. standard crossing gate, so that we have uniformity pretty well along.

Mr. Hoover said, after we had finished this report, that the work had just begun now. The next thing was to put it across and sell it to the municipalities, and get the Uniform Vehicle Code adopted by the states.

Chairman W. M. Post:—We have about three minutes to present what we consider a very important report on our assignment, Report on Increased Efficiency Secured in Railway Operation by Signal Indications in Lieu of Train Orders and Timetable Superiorities. I am afraid there is not time enough to do the report justice. I will try to make the presentation as brief as I possibly can.

This is our first report on this assignment. We have tried to show the beginning and the development of train operation by signal indication without train orders and timetable superiorities; also the economic advantages.

You will find on page 536 a table showing the installations arranged in chronological order.

I want to express the appreciation of the Committee for the painstaking research done by Mr. H. M. Sperry, which made it possible to prepare this report and particularly this table.

You will note that the oldest installation was over the Louisville Bridge, Louisville, Kentucky, on the Pennsylvania Railroad made in 1882, and I will read two or three paragraphs from the report; a brief description of this operation.

"The first installation of train operation by signal indication, as previously stated, was made in 1882 on the Pennsylvania Railroad at Louisville, Kentucky. At that time the line entering Louisville over the Louisville Bridge crossing the Ohio River was single track. Trains of the four roads using the bridge totaled 150 daily. As Standard Time had not come into use, trains were scheduled on the local time of the four roads, each one with a different time standard. This time difference made it practically impossible to operate trains by timetables and train orders, as any time interval method requires a single standard of time.

"To meet this unusual situation the space interval method was put into use by the installation on the eight miles of line of six manual block sections.

"The block signals were made the sole authority for directing train movements."

The second installation was on the Boston & Maine in 1883. The third installation, covering thirty-four miles on the middle track of a three-track line, was made by the C. B. & Q. Railroad in 1888. This appears to be the first installation on an extensive scale. Mr. Latimer, for many years Signal Engineer of the C. B. & Q., should be given credit for much pioneer work in connection with movement of trains by signal indication.

According to our records there are today over 100 installations on 31 railroads, with a total of 1736 track miles consisting of 613 miles of single track and 1150 miles of multiple track lines for either direction operation, for directing the movement of trains by signal indication, without the use of train orders.

The installation on the Pennsylvania between Huntley and Cameron in 1907 was the first installation having complete track circuits, with directional selection and check locking between block stations, together with electric locking of outlying switches. The circuits for this system were designed by Mr. C. C. Anthony, formerly Assistant Signal Engineer of the Pennsylvania Railroad. This complete safeguarding against possible mistakes by the operators satisfied many railroad officers that it was safe to operate trains on single track or against the traffic on multiple tracks by signal indication only. You will note that installations after 1907 were much more frequent.

We have called attention on page 525 to three methods of directing train movements:

(1) By timetable and train orders (a time interval method).

(2) By timetable, train order and block signal (a space interval method).

(3) By signal indication (a space interval method).

I will read a very few paragraphs under the heading of Economic Advantages of Train Operation by Signal Indication, pages 531, 532 and 533.

"A train order, ordinarily prepared on estimates of future performance, takes into account the movements to be made during an hour or more (often several hours) after the order is issued. Failure by the superior train to meet the expected performance ties up the inferior train. Because the train order system requires so much time it is not always possible to afford relief to the inferior train by new orders and substantial delays are unavoidable. Under operation by signals no time is required to change the lineup. The dispatcher can operate from minute to minute instead of from hour to hour."

"When delays are reduced and trains kept moving, track capacity is increased.

"When capacity of single-track lines is increased, double tracking (often prohibitive in cost) can be postponed."

There are several other interesting paragraphs but I will not take the time to read them.

This report is presented as information, but I wanted to state that in 1925 Committee XXI presented the following conclusion on its assignment, "The Economy Resulting from the Operation of Trains Against the Current of Traffic on Multiple Track Lines:

"Where the volume and distribution of traffic on a multiple track line are such as to cause delays to trains sufficiently serious to warrant the consideration of means of effecting relief, the operation of trains against the current of traffic is, with suitable protection, recommended as safe and as affording a means of increasing capacity at a small expenditure comparable with the cost of additional facilities sufficient to give relief."

This conclusion, which was approved, covered multiple track lines only. Experience has demonstrated that trains can be operated successfully on single tracks as well as in either direction on multiple track lines by signal indications properly controlled, in lieu of train orders and timetable superiorities.

I have consulted with Mr. Farrin, Chairman of Committee XXI, who agrees that the following resolution should be presented. I therefore move that the conclusion adopted by this Association in 1925 for publication in the Manual be withdrawn and the following substituted therefor:

"Where the volume and distribution of traffic on single or on multiple tracks are such as to cause congestion, overtime or delays to trains, directing the movement of such trains by signal indications in lieu of train orders and timetable superiorities is, with signals having proper safeguards to control the approach and movement of trains, recommended as safe, and as affording a means of increasing capacity or facilitating the movement of traffic."

Vice-President G. D. Brooke:—Mr. Post, as I understand it, what you propose is a revision of the present matter in the Manual of the Economics of Railway Operation Committee.

Chairman W. M. Post:—Yes, it merely brings it up to date to include single track as well as multiple track lines.

Vice-President G. D. Brooke:—I think the proper way to handle that will be to bring that up tomorrow when that Committee reports and ask for the change to be made at that time.

Chairman W. M. Post:—That is satisfactory.

Vice-President G. D. Brooke:—There are very few in the house at the present time, and I think that would be a better time to bring that subject up

Chairman W. M. Post:—There is one more report, Prepare and Submit as Information the Current Activities of the Signal Section, A.R.A., Supplemented with List and Reference by Number of Adopted Specifications, Designs and Principles of Signaling Practice. I will ask Mr. Vandersluis, Chairman of the Sub-Committee, to present that subject.

Mr. W. M. Vandersluis (Illinois Central):—This report is found on pages 543 to 548. It was found that the activities of the Signal Section generally were so great that it was an encumbrance to the literature to report through this Committee all the things they were handling.

For the convenience of the members there is given on page 543 a summary of last year's activities of the Signal Section. Extending through pages 544, 545, 546, 547 and 548 is a correct list of current specifications, for ready reference.

The standard plans of the Signal Section are rather voluminous, and reference is made only to pages 1 to 32 of the Signal Section Manual.

This is presented only as information.

Chairman W. M. Post:—That concludes the report of the Committee.

Vice-President G. D. Brooke:—Before discharging this Committee, I want to announce that Mr. Caldwell, a former member of the Federal Radio Commission, will address the Association tomorrow at twelve o'clock sharp. It is logical to look forward to an interesting address at that time, and I am sure you will all take advantage of the opportunity of hearing it by being here and bringing others who are interested.

This Committee is now dismissed with the thanks of the Association for the excellent work it has done. (Applause.)

DISCUSSION ON IRON AND STEEL STRUCTURES

(For Report, see pp. 953-1104)

Chairman A. R. Wilson (Pennsylvania) :—Committee XV announce with regret the death of Mr. A. F. Robinson, a long-time member of this Committee, who died on January 20. Suitable resolutions in memoriam were prepared by members of the Committee and appear in the March Bulletin on pages 321 and 322.

Your Committee respectfully presents herewith report covering the following subjects:

(2) Specifications for Steel Highway Bridges (Appendix A).

(3) Feasibility of electric welding of connections in steel structures (Appendix B).

(7) Uses of copper bearing steel for structural purposes (Appendix C).

(8) Effect of dead load on impact from moving loads on bridges (Appendix D).

(9) Rolling Tests of Plates (Appendix E).

(10) Punched and Reamed Work (Appendix F).

The report of this Committee is found in Bulletin 314.

The action recommended is that the report on specifications for steel highway bridges be approved and inserted in the Manual.

This report is presented for action by the convention at this time. I shall call on Mr. J. B. Hunley, Chairman of the Sub-Committee on Specifications for Steel Highway Bridges, to make a statement prior to action of the convention.

Mr. J. B. Hunley (Cleveland, Cincinnati, Chicago & St. Louis) :—As the title page explains, this specification was prepared by a Conference Committee representing the American Association of State Highway Officials and the American Railway Engineering Association. This Committee first met, I think, about three years ago, and it soon become apparent that it would be ideal and quite feasible to get out a joint specification. This Conference Committee considered the tentative A.R.E.A. Specification for Steel Highway Bridges which had come out the previous year, and also the existing specification of the highway officials. We took the best of each of those specifications and some parts of both specifications we discarded altogether, trying to get something better. The work was not hurriedly done by any means.

I believe we worked on it three years solidly and had two-day meetings almost every month, so that it represents a good deal of study.

After the Conference Committee agreed on the specification and presented it to its respective parent committees, certain changes were suggested by the parent committee. The Conference Committee considered these changes and ironed out the disagreements. It was last August, I believe, that the Conference Committee presented its final specifications.

On the part of the A.R.E.A., the specification was approved by Committee XV and it was decided to submit it for adoption by this Association. The specification was also approved unanimously by the Committee of Bridge Engineers of the American Association of State Highway Officials, and it is my understanding from Mr. Kelley, chairman of that committee, that if this specification is adopted by this Association it will immediately be adopted by the American Association of State Highway Officials.

We feel that it is very important to have a joint specification, and I think it was very fortunate that we could agree on a specification which was satisfactory to both associations. I think we all feel, regardless of what attitude the Association may take, that it is the best specification which can be obtained at this time. It, of course, may be subject to revision later, but it is a step forward.

Mr. Robert H. Ford (Chicago, Rock Island & Pacific) :—I think the Committee are to be congratulated on the excellence of the specification and the forward step they have made in connection with its preparation.

I should like to call the convention's attention to the diagram on page 976 which conforms with part of the specification. This, in itself, is a decided step in advance because it forms a standard method. Hereafter, the railways may deal with the highways on this question of width of lanes. This you will note gives a multiple of traffic lanes, it sets specifically the width of a traffic lane so that hereafter you can get away from this arbitrary question of the widths of highway bridges. There is a determination there and it ought to work not only for the benefit of the highways, but of the railways as well.

I want to compliment the Committee on the excellence of their work.

Chairman A. R. Wilson:—We formally move that the report of this Sub-Committee on Specifications for Steel Highway Bridges be received, approved and inserted in the Manual.

The President:—It is moved and seconded that Appendix A on page 955, Bulletin 314, be adopted as Specifications for Steel Highway Bridges for 1929. Is there any discussion or observation on this motion?

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western) :—My objection is to the diagram on page 977 and that on page 978 so far as it affects the 16-foot vertical clearance. We down on the Lackawanna conflict with the Public Service Commissions and Bureaus of Public Roads because of this excessive clearance, and we have won out in the majority of cases so that they have permitted us to use 14-foot clearance with trolley lines, notably in recent grade crossing eliminations for the cities of Elmira and Binghamton in the State of New York. Whereas, the city originally requested 15-foot clearance for crossings with street cars, we convinced them that 14-foot clearance was more than sufficient.

Mr. J. B. Hunley:—Do I understand the objection raised refers to a subway? It must be borne in mind that this does not apply to a subway. This applies to overhead bridge or through bridge where the structure would be carried over the railway track.

Mr. Meyer Hirschthal:—This refers to another crossing under our tracks with a width perhaps as great as 60 and even 100 feet.

Mr. J. B. Hunley:—This would hardly apply to that. This specification could cover the design of structure over your tracks carrying the street railway.

Mr. Meyer Hirschthal:—What is over the street railway?

Mr. J. B. Hunley:—This is a highway bridge carrying a street railway.

Mr. Meyer Hirschthal:—What is over the street railway? Is not the railroad track over the street railway?

Mr. J. B. Hunley:—I think the ordinary case would be where you are designing a structure to carry a street railway, in either a street or roadway. This specification would not cover the design of a structure carrying your tracks over a street railway.

Mr. Meyer Hirschthal:—What I mean to object to is our maintaining a 16-foot vertical clearance, because if we decide that 16-foot vertical clearance is what is required over our tracks it would be just as logical to expect 16-foot clearance under the tracks.

The President:—Is there any further discussion on this particular report with special reference to pages 976 and 977? If not, it is the desire of this Committee to bring this question of the specifications to an issue on the basis as presented. There being no further observations, the vote will be clearcut on the question of Appendix A, page 955, voting on them as a whole. There being no objection, they will be taken as a whole.

Mr. L. W. Skov (Chicago, Burlington & Quincy):—On page 983 appear three diagrams showing loading. I wonder if the Committee, in its study, took into consideration the effects of trains of trucks and trailers. Some of the states in the Middle West permit loading 24 per cent heavier than the heaviest one of these loadings shown, on 40-foot spans; 34 per cent heavier on 50-foot spans and 50 per cent heavier on 60-foot spans. That is for one lane of traffic. The laws of several of the states here in the Middle West will permit of such loading on the highways. It is not uncommon in this part of the country to see large trucks hauling two, or possibly three, heavily loaded trailers back of the truck.

Then there is another question on page 988, under Longitudinal Force, Article 1115, which reads, "Provision shall be made for the effect of a longitudinal force of 10 per cent of the live load on the structure, acting four feet above the floor." That, I take, is meant to affect the design of bracing of towers, and so forth.

It occurred to me that the last part might well be omitted, "acting four feet above the floor." If there is 10 per cent longitudinal force acting on the structure it would be applied at the floor. In addition there would be a couple producing vertical reactions. Assuming the wheel spacing to be 14 feet, 10 per cent of brake effort or tractive effort would produce 2.9 per cent additional vertical reaction on one set of wheels, a rather small factor, especially when the impact called for in Article 1114 provides for 38.4 per cent impact on a 5-foot span and 37 per cent on a 20-foot span. Therefore, it seems this additional factor of applying braking action four feet above the floor might well be eliminated.

The same thing holds true of Article 1117, where the force is also applied four feet above the top of rail. There the lateral force on a standard gage car would produce 8½ per cent increase in vertical reaction on the outer rail. The impact allowances would be the same as stated above.

I therefore think the reference to the acting four feet above the floor should be eliminated. I will make that as a motion, to eliminate that part of Article 1115 and 1117 which refers to acting four feet above the floor, or four feet above the top of rail.

The President:—Mr. Hunley will make some explanation of the four-foot horizontal force.

Mr. J. B. Hunley:—I do not think it should be eliminated at all. We have the same provision in our railway specifications. It is true that the 10 per cent longitudinal force, regardless of where it is applied, whether applied at the roadway or 4 feet above, does at once give you the shear in the longitudinal bracing, but this additional four feet produces a greater direct stress in the columns of a tower, when applied four feet above the roadway.

Of course, that four feet was assumed as representing the center of the gravity of the load. You have that additional couple of four feet and your longitudinal force which produces that much greater vertical force in the legs of the tower regardless of whether your trucks are 14 feet long or not. Your load is really one tower span plus an intermediate span. It is on the safe side, and I do not think it should be taken out.

The same remarks would apply to the centrifugal force. The centrifugal force alone produces the shear in the transverse bracing, but of course the four feet greater lever arm produces that much greater overturning moment. I would dislike very much to see either one of those come out.

The question of the loading was discussed very thoroughly with the highway representatives, and they are in much better position to know the tendency or trend to increase loads than we are, and it seems to be their feeling, almost unanimously, that the truck loads are going to decrease rather than increase; and, in fact, most states now are designing for a maximum loading of the H-15 truck loading. They really felt this H-20 loading, which we have shown here, was practically the maximum and quite high. Prosperous states now are designing for H-15 and the H-10 loading. In this truck spacing and truck loading, 30 feet was actually measured from experiments. They ran truck trains and got the average distance between trucks under various conditions of travel. That is how this was arrived at.

It is true that we do have an occasional load with a heavy trailer load that will produce a heavier load than this H-20, but they are rare and we do not have solid trains of them. There will be no single lane bridges built for H-20 loading, and the possibility of having multiple lanes loaded with anything heavier than H-20 we felt was so unlikely it should not be taken into account.

Mr. Robert H. Ford:—I hope the motion will not prevail and that the Committee will be supported in their specifications.

The remarks from the floor are very interesting, but they amount to very little as a matter of practical effect.

I was talking with the Chief Engineer of one of the principal states about this specification recently, and he said to me that after a very thorough study he felt, so far as the highway people were concerned, it would be a great step in advance. I know, so far as the railroads are concerned, it is a very necessary and very desirable thing. It is to be presumed as years go by that we may find something that may require some modification, but the great need now is a specification. It has been pending here for some time, and I hope the Committee will be supported in the specification they brought forward.

Mr. L. W. Skox:—I should like to add as a matter of information that the maximum load of any truck thus used is 16,000 pounds on axles, and that there are trucks operating over state highways in Illinois today that are hooked up in trains of that kind. It was not long ago that a train of fifty of them came into Chicago at one time. However, I do not think they were loaded to 16,000 pounds per axle but it shows that there are a good many truck trains being operated.

I have one more question to ask, and that is regarding Article 1202 on pages 990 and 991. There is a formula given there for distribution of loads on slabs where the reinforcement is transverse to the axis of the bridge. I am wondering if that provision is supposed to cover the thin slab between heavy T-beams in long spans, where frequently the tee part of the beam is only 6 or 7 inches deep and the stem may be 2 feet or 2½ feet wide by 3 or 4 feet deep.

Mr. J. B. Hunley:—This specification may or may not cover the T-beam construction. This specification is a specification for steel bridges and not a specification for concrete T-beam construction. It is only meant to apply to the reinforced slab supported on girders or stringers with reinforcement either transverse or longitudinal with the direction of traffic.

This formula was based on results of experiments made by Mr. A. T. Goldbeck, of the Bureau of Standards, and does not apply to T-beam construction. We do not know what that distribution would be in T-beam construction. Keep in mind that this specification is for steel bridges and this part is a concrete slab on steel members. We do not know what that would be. We are not saying that this would apply to T-beam construction.

The President:—Mr. Skov made a motion regarding the four-foot position above the floor. It was not seconded. The Committee as a whole desires the issue to come on the main specification as a whole, page 955, "Specifications for Steel Highway Bridges—1929."

There being no objection to putting it as a whole, the issue will be submitted on the specification in toto.

Those in favor of adopting specifications mentioned on page 955 will please indicate their approval by saying "aye." The "ayes" have it, and the motion is carried.

Mr. Meyer Hirschthal:—I did not want to make a motion on this clearance but I want to have the Committee take under advisement the reduction of the 16-foot clearance, so we do not commit ourselves to that dimension to be used as a weapon for the state highways.

Chairman A. R. Wilson:—We shall take that under advisement. There is no doubt that when the specifications are in the hands of the various engineers for working, we will have a number of comments which we shall have to take under advisement.

"(3) That the report on the feasibility of electric welding of connections in steel structures be received as information." This is covered in Appendix B, page 1014. We ask that this report be received as information.

The President:—If there is no objection, it will be so received.

Chairman A. R. Wilson:—Subject 7, that the report on the uses of copper bearing steel for structural purposes be received as information (Appendix C), page 1015.

The President:—If there are no questions or objections, it will be so received. There will be a comment made by Mr. Wilson first.

Chairman A. R. Wilson:—This morning we are in receipt of a written comment from Mr. J. R. Wilks. He states generally that the information we present in this report is somewhat contradicted by Circular 253 from the Bureau of Standards. We should like to have this written comment appear in the Proceedings.

The President:—There being no objection on the part of the Association, with the consent of those present, the Chair will order that it be so printed. It is headed "Comments on Report of Committee on Iron and Steel Structures, Appendix C (7), Uses of Copper Bearing Steel for Structural Purposes," by Mr. J. R. Wilks.

Past-President D. J. Brumley (Illinois Central):—If that article is not too long I should like to suggest that it be read for the benefit of the convention.

The President:—It will take about four or five minutes.

Chairman A. R. Wilson:—"Comments on Report of Committee on Iron and Steel Structures, Appendix C (7), Uses of Copper Bearing Steel for Structural Purposes.

"This report is of general interest, since there has been a problem as to just what should be used to prolong the life of railroad equipment. We all recognize that investigators for the past 25 years have been searching diligently for ferrous metal that would reduce the cost of excessive corrosion losses. These losses have been estimated by some investigators to now reach the tremendous total of many millions of tons per year. A great deal of progress has been made, but it is important that the practical engineer study the subject carefully before reaching a conclusion as to which of the ferrous metals offered by the producer would best suit the specific purpose he has in mind.

"There is a very recent example showing an astonishing reversal of opinion. In July, 1924, in the Iron Trade Review, there appeared an article concluding that the presence of copper has prolonged the service life of plates on the Leviathan. A month or so ago, or five years later, the Bureau of Standards issued comments based on more complete information. These comments completely reversed the earlier opinion, as follows:

" 'The Bureau has been advised informally that in very recent inspection of this ship in dry docks, no distinct difference in the surface conditions of the original copper bearing steel plate and of the ordinary steel plate without copper, that had been inserted subsequently, was to be observed.

"'This would appear to add further evidence to the conclusion that additions of copper, within the limits usually employed, confer no decided improvement in the corrosion resistance of steel when more or less completely immersed, and would indicate that other factors play an important role in cases where the copper bearing or non-copper bearing steel shows superior behavior to the other.'

"This substantiates the most common warning by investigators of corrosion. As stated in the Bureau of Standards Circular 253, September 13, 1928:

"'A common error in consideration of corrosion test is to assume that satisfactory or unsatisfactory performance under one set of conditions means that the performance will be similar under another set of conditions. The relative standing of different materials is often altered as the conditions are altered.'

"Dr. F. N. Speller in his recent book 'Corrosion—Causes and Prevention,' bears out this statement when he says:

"'That there is no all-round test for all classes of corrosion is now well understood from the very complexity and variability of the factors involved. Such tests should be checked against the actual life of the material in service to determine the reliability as a basis of comparison.'

"The Bureau of Standards in the circular referred to above, No. 253, also states on page 13:

"'In the American Society for Testing Materials program of total immersion tests, the same series of materials employed in the atmospheric tests were introduced. . . . The results clearly show that corrosion-resistance of iron and steel when submerged is practically uninfluenced, within the range of the tests, by copper contents.'

"It is believed that there is danger of the Committee's report being interpreted as unqualifiedly endorsing the selection of copper bearing steel for all kinds of service, whereas such cases as quoted above clearly demonstrate that such an interpretation would be unwarranted.

"We know there are a great many inequalities to be found in steel and it will be generally agreed upon that the presence of a small amount of copper cannot compensate these inequalities.

"Proper selection of different metals with respect to the conditions in which they will serve is certainly most advisable."

Mr. H. T. Livingston (Chicago, Rock Island & Pacific):—That paper you just read covers practically the remarks I wanted to make. The information submitted does not actually draw conclusions but they are, apparently, somewhat inferred. For the reason that this thing seems to deal somewhat in generalities, it would be somewhat dangerous to draw conclusions to particulars from the information submitted.

The President:—Mr. Wilson points out that the comments just read were largely discussed, and the information of this Appendix will be received and put into the Proceedings.

Chairman A. R. Wilson:—Subject No. 8, Effect of dead load on impact from moving loads on bridges, Appendix D, page 1017. We ask that this report be received as information.

The President:—If there are no comments or questions it will be so received.

Chairman A. R. Wilson:—Subject 9, Rolling Tests of Plates, Appendix E, page 1027. We ask that this report be received as information.

The President:—If there are no comments or questions it will be so received.

Chairman A. R. Wilson:—Subject 10, Punched and Reamed Work, Appendix F, page 1078. I shall call on Mr. Dufour, Chairman of the Sub-Committee, to make a statement.

Mr. F. O. Dufour (United Engineers and Constructors):—In Bulletin 314, Appendix F, pages 1078 to 1104, inclusive, is presented the report of the Sub-Committee on Punched and Reamed Work.

At the convention held in March, 1928, the Committee recommended that Article XII, Workmanship, in General Specifications for Steel Railway Bridges, issued August, 1925, third edition, be revised and received as information. (See Appendix A, report of Committee on Iron and Steel Structures, Proceedings, Volume 29, page 367.)

This year's report is a digest of the report made in 1903 and also a log of the tests made in 1923, together with a digest of the same. Why the results are, what they are, or why they are not otherwise, is, of course, something we are unable to determine. These data are the results of tests carefully made with modern equipment and the employment of approved and accepted methods.

This coming year this Sub-Committee will consider and analyze further these data and the article on Workmanship, and at the next convention we expect to make a final report.

The matter in Appendix F, pages 1078 to 1104, is therefore offered as information, and it is recommended that it be received as such.

Chairman A. R. Wilson:—On Subject No. 1, Revision of the Manual, investigations and tests on a number of subjects are under way, including the allowable bearing pressures on large rollers, testing of I-beams in groups, investigating the economy in the use of copper bearing steel for structural purposes, effect of dead load on impact from moving loads. The work on these subjects has not progressed sufficiently to enable the Committee to make any recommendations for revision.

A Conference Committee composed of members of Committee XV and representatives of the American Society of Civil Engineers have been diligently at work drafting Specifications for Steel Railway Bridges. This work has been practically completed and it is expected that the Committee will present this year the Specifications to their respective organizations for adoption.

No definite progress was made during the year on the other three subjects of the Committee's Outline of Work given below:

(4) Undertake the study and behavior of bridge pins under test loads.

(5) Report on test of I-beams in groups.

(6) Undertake the testing and study the behavior of steel columns under test loads.

The President:—Are there any comments or questions for this Committee to answer? If not, the Chair wishes to record the appreciation of this Association to this Committee. I think all the members here who have been members for many years know of the records and achievements of this Committee in connection with the production of steel bridge specifications. It is a pleasure to have a Committee who can produce this work, as do many other committees. I feel it is due them to make this comment, and with the thanks of this Association this Committee is excused. (Applause.)

DISCUSSION ON WOODEN BRIDGES AND TRESTLES

(For Report, see pp. 1145-1227)

(Vice-President Louis Yager in the Chair.)

Chairman W. E. Hawley (Duluth, Missabe & Northern):—The report of Committee VII is found in Bulletin 314, page 1145. This report will be taken up in sections by the Chairmen of the Sub-Committees. I shall call on Mr. Austill to present the report of the Committee on Revision of Manual.

Mr. H. Austill (Mobile & Ohio):—The Revision of Manual is in Bulletin 314, commencing on page 1147, Appendix A.

In order to avoid confusion by referring only to proposed changes, the specifications that were adopted in 1927 for printing in the Manual are reproduced with such changes as the Committee recommends on pages 1147 to 1204, Bulletin 314.

With the exception of material to be withdrawn from the Manual, the changes are largely editorial. Structural grades of lumber and timber and method of their derivation, pages 355 to 360 of the 1927 Proceedings, are withdrawn from the Manual and appear in Appendix B of this report for adoption as information.

On page 1177 under Introduction to Structural Rules the Grade of Select Southern Pine is withdrawn and the grade of dense common is added for fir and pine. The reference code on pages 371 to 385 of the 1927 Proceedings, which now stand approved for the Manual, will be revised at a later date to conform with the changes now proposed, if these changes are adopted.

The changes, as stated, are largely editorial. The Committee will be glad to answer any question. Mr. Chairman, I move the adoption of Appendix A, Revision of Manual.

Vice-President Louis Yager:—The question is before you on the adoption of the material appearing in Appendix A. This matter has been before you for some time. The Committee now desires definite action. Are there any questions which you would like to direct to the Committee relating to the changes which the Sub-Committee Chairman has indicated? If there are no questions or observations, the question to be definitely acted upon is the approval of this matter submitted in Appendix A. Those in favor will signify by saying "aye"; contrary "no." It is so approved.

Chairman W. E. Hawley:—Subject-matter under No. 2 will be presented by Mr. John Newlin, of the Forest Products Laboratory.

Mr. J. A. Newlin (Forest Products Laboratory):—In applying the foregoing specifications, a great many people are like myself, they will want to know the principles back of those specifications. Appendix B sets forth these principles. It gives the principles of the grading rules without giving the information back of them. Those principles together with the detailed information have been enunciated from time to time and may be found in various publications.

Starting on page 1206 of Bulletin 314 the first part of Appendix B gives the principles back of grading rules in words, after which there is given a numerical evaluation of these principles, so that working stresses may be assigned to timbers that do not meet the specifications. The last part of the Appendix is merely charts and equations, which make this application of the principles a little bit easier.

I think Appendix B has great value for those who are working on grading rules and who really want to understand the principles back of the specifications that have been adopted.

Vice-President Louis Yager:—This is very interesting information, particularly to those of us who are not specialists in timber in its various phases.

Are there any questions in connection with any of the details of this Sub-Committee's report that you would like to put to the Committee? If not, the material will be received as information.

Chairman W. E. Hawley:—The report of the Committee on Subject 3 will be presented briefly by Mr. Grear of the Illinois Central.

Mr. S. F. Grear (Illinois Central):—The report and conclusions of this Sub-Committee are found on page 1225, Bulletin 314. The report is very brief and the recommendation is that the establishment of such store yards is not a feasible proposition at the present time and that the subject be dropped from further consideration.

Vice-President Louis Yager:—If there are no objections, the report will be received as information and the assignment dropped.

Chairman W. E. Hawley:—The report of Sub-Committee on Overhead Wooden Bridges, Subject 4, will be presented by Mr. Austill.

Mr. H. Austill (Mobile & Ohio):—Subject 4, Study and Report on Overhead Wooden Bridges, is given in Appendix D, page 1226 of Bulletin 314, and is presented as information.

The Sub-Committee desires to thank you for the response to the questionnaire and the interest shown in its work and invites now remarks and criticism. The response to the questionnaire was most satisfactory, but as to wearing surface, it was somewhat unsatisfactory and disappointing. Most replies merely stated the type that has been used, without comment.

In connection with state highway departments, the state of Alabama has developed a design in which the bridge is built of creosoted pile and timber throughout, except a reinforced concrete slab is used for wearing surface; the curb and hand rail is also reinforced concrete. This seems to prove to be a very economical bridge. The State Highway Department has furnished us with plans and quite a bit of information on this design which is somewhat new in combining timber and concrete.

The cost seems to about balance between a four-inch timber floor with some form of wearing surface and this reinforced concrete slab which is a combination floor and wearing surface. As stated, the report is presented as information. It is a new subject and the Committee hopes during the coming year to develop some plans that may be of interest to you.

Mr. B. R. Leffler (New York Central):—If it is in order I thought it might be appropriate to make a few remarks regarding Appendix D.

I think this is a fine beginning. We railroad men should consider the utility of timber for overhead bridges. We have been passing, or are passing, through an age of poor concrete, and I am afraid we have overlooked the benefits of well-designed overhead bridges, built of treated timber. About 1906, under my jurisdiction, there were built a number of overhead bridges between Chicago and Buffalo. These were built out of fir and were treated with carbolineum. We are now taking those bridges out after twenty-three years of service. It is hardly necessary to observe that these bridges carried about the heaviest highway traffic.

With the present method of thorough treatment I am bold to say that such treated timber bridges will last just as long as concrete, at least as long as some of the concrete structures we have been building. I do not think we should allow our experience with untreated timber in the past to measure the benefits that may be derived from properly designed and properly framed and properly treated timber bridges.

One object that I had in talking about this was to bring out the fact that, especially in the Eastern states, there is a prejudice against timber bridges on the part of the state highway departments, and in approaching joint projects these highway departments seem to be against timber bridges and for concrete bridges.

Another important feature, too, is this: The cost for these bridges is only about a third to a half of what a concrete bridge will cost. It is also a fact that in the Western states and the Southern states where timber is a more accessible product, treated timber bridges have been very favorably considered and are being built. I think the Eastern railroads should give this question of treated overhead bridges favorable consideration.

(The motion was put to a vote and carried.)

Chairman W. E. Hawley:—On behalf of Committee VII I want to thank Mr. Leffler for the remarks he contributed to this discussion. In our district we feel that many of the roads have not received their final location. The tendency has been to build so-called permanent bridges and then we find that a revision of the road plan has resulted in possible changes of bridges, changes of width or grade, and that if the bridges had originally been built of timber considerable money would have been saved at the time of change.

Also, in conjunction with the remarks made by Mr. Ford at the meeting yesterday, it has not been definitely settled as to the proper division of costs of overhead bridges, and a timber bridge costing less money at the present arbitrary method of division of cost will probably prove more economical in many cases for both parties, both the public and the railroad, than more permanent structures.

The Committee is openminded on this subject. They know that wooden bridges will not cover all requirements at all overhead crossings of railroads, but we want to investigate it and where wood is suitable we want to bring in the recommendations that will enable the engineers to give wood a fair consideration in designing an economical crossing.

Mr. H. Austill:—Mr. Hawley mentioned first the division of cost. We had proposed crossings in which the state proposed to divide the expense fifty-fifty, and submitted plans for reinforced concrete. We said that the material which would carry the loads to serve our purpose was good enough for us in our own trestles, and that we would contribute 50 per cent of the estimated cost of the creosoted timber structure.

The Highway Department, after some consideration, agreed to those terms. They built the bridge of reinforced concrete. We paid 50 per cent of the estimated cost of a creosoted timber structure at a good saving to the railroad and since that time we have made three later agreements on the same basis and, finally, the states, since then, have built two bridges and built them of creosoted timber where crossing our line.

Vice-President Louis Yager:—This discussion indicates very clearly that there is not very much foundation for the fear in some quarters that the usefulness of this Committee might soon terminate. They are finding more and effective uses for timber.

This concludes the presentation of this Committee's work and they are excused with the thanks of the Association for their efficient work. (Applause.)

DISCUSSION ON MASONRY

(For Report, see pp. 781-815)

(Vice-President Louis Yager in the Chair.)

Chairman C. P. Richardson (Chicago, Rock Island & Pacific):—The report of the Masonry Committee this year is in Bulletin 313, pages 781 to 815, inclusive.

Your Committee reports on four of its seven assigned subjects. There has been consideration given to the other subjects but no findings reported at this time.

Before proceeding with the report, I should like to take a few moments in honor of our late Vice-Chairman, Mr. Job Tuthill. Mr. Job Tuthill is well known to the members of this Association and has been Vice-Chairman of the Masonry Committee for several years. He has represented the Association on the Joint Concrete Culvert Pipe Committee, and on the Joint Committee on Plain and Reinforced Concrete. As you all know, he was active in this work up to the date of his very short illness resulting in his death on December 28th last. Mr. Tuthill has been one of the members of the Masonry Committee always on hand when the meeting was opened. Announcement of Mr. Tuthill's death is to be found on page 782, with a resolution of sympathy prepared by the Committee. A proper memoir will appear in a subsequent Bulletin.

My attention has been called that during a discussion of the Masonry Committee report last year the question of railway companies furnishing cement on contract jobs was brought up and the Committee requested to give this subject consideration during the year. I mention this as we have not reported on that subject in the printed matter.

Your Committee feels that the matter of either the railway or the contractor furnishing the cement on masonry work is one that each railway must necessarily decide for itself, having in mind economics in the original cost as well as other thoughts which need not be mentioned.

I believe it must be conceded that railway engineers in adopting, as they have, the water-cement ratio of control of the strength of concrete, the matter of skimping on the use of cement can be dismissed, as the representative of the railway company is in charge and is observing the manufacture of concrete to-day.

I do not mean to preclude any further discussion of this subject, but will state, however, that if there is a lively interest in ascertaining what the general practice is throughout the country, the Committee will gladly send out a questionnaire. But it is the thought of the Committee that the answers received from this questionnaire would be just a matter of practice and not of sufficient uniformity to allow of any conclusion which could apply to railways in general.

The first section of the Masonry Committee report is on principles of design of concrete, plain and reinforced, for use in railway structures, found in Appendix A, pages 783 to 803, inclusive, and will be presented by Mr. Hirschthal, Chairman of the Sub-Committee.

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—The Committee on Masonry, through its Sub-Committee on Design, has made further progress in its aim to provide specifications on the design of all structures or members of concrete and reinforced concrete. This year the Committee presents the principles of design of concrete, plain and reinforced concrete as applied to columns for adoption and printing in the Manual.

I move for such adoption, reading, by permission of the Chairman, the headings of the various sections, stopping sufficiently to permit of any comments.

The heading is "Columns." Paragraph 121. Limiting Dimensions. 122. Unsupported Length of Columns. 123. Design of Spiral Columns.

Vice-President Louis Yager:—If there are any members who would like to raise any questions or make any comments, opportunity is given while the Sub-Committee Chairman pauses.

Mr. Meyer Hirschthal:—On page 784, at the end of the first paragraph, there is a typographical error: It should read "for plain bars" instead of "for plan bars."

Paragraph 124. Design of Columns with Lateral Ties. 125. Bending in Columns. 126. Long Columns.

This concludes the subject matter of Columns, and I will proceed with my motion to adopt this section for printing in the Manual.

Vice-President Louis Yager:—You have heard the motion, and its second, that the matter in Appendix A, outline relating to Columns, be approved as recommended practice for the Manual. Are there any comments or discussion? If not, those who are in favor of the motion will signify by saying "aye"; contrary minded, "no." It is approved.

Mr. Meyer Hirschthal:—The second subject, specifications for design submitted to this convention, is that of Culvert Pipe. This subject has been in the hands of a Joint Committee for a number of years, and finally has resulted in a second report by this Joint Committee on Concrete Culvert Pipe.

The representative of this Committee on the joint committee was the late Mr. Job Tuthill, who recently passed away. We were to collaborate with the Committee on Roadway, but Mr. Tuthill told me he was unfortunately unable to come in contact with that Committee to have a meeting whereby we could agree on any changes necessary. The Masonry Committee has gone through these specifications and made slight revisions, in which form it presents this specification for adoption by this convention and printing in the Manual.

The Chairman calls my attention to the fact that the changes that were proposed were countermanded and this specification is presented as submitted by the Joint Committee. I move its adoption.

Vice-President Louis Yager:—The motion and its second relate to the specifications which have just been outlined to you by the Sub-Committee Chairman, and they desire to present these specifications for adoption at this time. Are there any questions or comments? Those in favor of the adoption of this motion will signify by saying "aye"; contrary minded, "no." It is adopted.

Mr. Meyer Hirschthal:—The third subject that this Committee presents, it presents as a matter of information, and the subject-matter is that of Flat Slabs.

In the past few years monographs have appeared in the Proceedings by the speaker, but this year we have advanced somewhat further in our conviction that we should have a provision for design of the girderless flat slab construction, and we present the subject of Flat Slabs information as a tentative method of design.

I move that this be received as information.

Vice-President Louis Yager:—If there are no objections to the contrary, it is so received.

Chairman C. P. Richardson:—The second section of the Committee report is on the subject of progress in the Science and Art of Concrete Manufacture, found in Appendix B, pages 804 to 812, inclusive. This section of the report will be presented by Mr. L. W. Skov, Chairman of this Sub-Committee.

Mr. L. W. Skov (Chicago, Burlington & Quincy):—Section (3) is divided into two parts: the first part covers special cements and admixtures and gives the definitions for same. They appear on page 804 and cover "Quick Setting Portland Cement, High Early Strength Cement, Super-cement, Admixture, Integral Waterproofing and Accelerators."

It is recommended that the subject-matter shown under these headings on page 804 be inserted in the Manual as recommended practice.

The remainder of the report on pages 804 to 812 is submitted as information and covers various methods of measuring moisture and aggregates. The subject matter to be included in the Manual ends on page 804 with the paragraph on "Accelerators."

Vice-President Louis Yager:—You have heard the motion on the adoption of subject matter just discussed by the Sub-Committee Chairman. Is there any discussion?

Mr. B. R. Leffler (New York Central):—Has the discussion been closed on this subject? If it is in order, I should like to add a few remarks concerning the subject, the Science and Art of Concrete Manufacture.

I thought it might be of interest to mention a few of the recent hopeful developments during the past year. Some time in the early part of the year, or rather at the June Convention of the American Society for Testing Materials, a paper was presented by a Kansas State Engineer bearing on the permanence of concrete. This engineer took a Frigidaire freezing apparatus and subjected specimens of concrete to alternate freezing and thawing action. He brought out that concrete made with more than seven gallons of water to a sack of cement would not hold up under such treatment.

The next important paper that was brought up before the American Society for Testing Materials pertained to the testing of concrete subject to alkaline water. Those tests to me seem to be important and interesting. They are probably not final tests, but they are suggestive.

That engineer tested about 30 different brands of cement and found, as I remember the result, that about a dozen, not over a dozen, of these brands of cement held up well under the sodium sulphate tests.

I mention these two papers in the hope that the Committee will keep watch, as it were, on these subjects, and if there are any further developments, note them carefully. It seems to me these two lines of investigation should bring out some rather interesting results.

The third paper was presented by Mr. Roderick B. Young, who is a well-known authority in Canada, on the permanence of concrete. His study was based on the observation of existing structures and not on laboratory tests. The interesting conclusion brought out by Mr. Young was to the effect that you cannot make permanent concrete with less than five sacks of cement per cubic yard of concrete in place.

These three points, it seems to me, are decided steps toward making better concrete in the field.

We have heard considerable about the water cement ratio. I think the water cement ratio as a means of bringing about good concrete is all right if used with care.

I have adopted the following: We are using six gallons of water to a sack of cement; the six gallons cover moisture in the aggregate which, roughly, runs about two gallons. Such concrete at the end of 28 days will test from 2,500 to 3,000 pounds; this kind of concrete is used in ordinary bridge work. The concrete is rather stiff and at first some objection was made to it, but we find no trouble in using it. We have been using it for about three years.

The danger in the water cement ratio, as I look at it, lies in this: If you look at it purely from a strength standpoint and say, "Look at the curve, the water cement ratio is one and we will get concrete at 1,500 pounds at the end of 28 days, therefore it is good enough for the retaining wall"; my viewpoint is entirely different. I place a secondary value on strength of concrete, but I place a high value on permanency and let strength take care of itself. There is no need to worry about the strength. The danger in the water cement ratio lies in the fact that it gives the resemblance of an exact science to the matter.

The French engineers many years ago, long before the water cement ratio was thought of, knew the bad effects of excess water in cement. The use of excess water in cement in this country was brought about by the rapid development of reinforced concrete. It was found that you could get the stuff around the bars more easily if you used lots of water. That is the story. We should go back to the older concrete which the French engineers long ago developed, just as little water as posssible. Don't put too much emphasis on strength; put it on permanency.

Chairman C. P. Richardson:—I am very glad that Mr. Leffler took that time. I know we are short of time, but I feel that we are apt to pass over too lightly the matters contained in the progress report of this Sub-Committee. It is of interest to everybody, but when nothing is said, a lot of the main facts in this subject are lost. I want to thank Mr. Leffler for his remarks.

Mr. Meyer Hirschthal:—There is one point I want to add to this reply of our Chairman in connection with Mr. Leffler's criticism. The trouble with concrete as far as permanence is concerned is not so much in the ingredients that are put in the concrete as in the workmanship. There is a tendency on the part of railways in particular to rush concrete work, and whereas it is perfectly well understood that it takes a carpenter to put up woodwork, a steel man to put up steel and a mason to put up brick or masonry, concrete is supposed to be put up by anything or anybody that is around with very little or no attention. If some attention were paid both by the inspector of the railway and the superintendent for the contractor to seeing that the working of the concrete in its forms was so thoroughly made that there would be a thorough conglomeration of all the material and set up into a real stonelike texture, we would get permanence of concrete.

That fact is testified to by the fact that in cement finish work where machinery is used, there results a concrete which is far superior to the ordinary concrete done by manual labor on ordinary bridge work.

Vice-President Louis Yager:—I desire to remove any erroneous impressions that the Chairman may inadvertently have given you. There is plenty of time for such discussion as this. It is very interesting and, I am sure, profitable and will be utilized by the Committee in its further labors on this subject. Are there any further comments?

Chairman C. P. Richardson:—Before passing from this subject I want to state that the Committee, with some hesitation, took hold of the subject of High Early Strength Cements and Admixtures and in its report brings out the claims of the various uses of these admixtures.

I have in my hand about five typewritten pages of discussion of this report on Admixtures. It was received from a well-known producer of diatomaceous silica and as it is rather lengthy I will not read it and would not suggest it being put into the Proceedings. I want to assure the writer of this discussion that it will be given consideration by the Committee during the coming year.

The third section of the Committee's report will be found in Appendix C on pages 813 to 815 and covers the subject of General Practices for Waterproofing Railway Structures.

This report is presented for information and includes a brief progress report showing the activities of the Committee, also a portion of a questionnaire which was published last year but unintentionally omitted from the publication of the Proceedings.

Vice-President Louis Yager:—If there are no further observations, this concludes the Committee's report and they are excused with the thanks of the Association. (Applause.)

DISCUSSION ON RECORDS AND ACCOUNTS

(For Report, see pp. 575-652)

Chairman J. H. Hande (Baltimore & Ohio):—This Committee has some seven subjects this year, in only two of which is material offered for the Manual. Our assignment No. 1, Revision of the Manual, requires no recommendations. Subject 2, Appendix B, Collaborate with Other Committees in the Preparation and Design of Forms Pertinent to Their Work, will be presented by Mr. Allen, Chairman of the Sub-Committee.

Mr. E. Y. Allen (Reading Company):—Last year this Committee presented a list, arranged under the general classifications of Design and Construction Department, Maintenance Department and Valuation Department, of all the forms used in routine railway operation which were included in the 1921 Manual and subsequent Bulletins. It is the purpose of this Committee to compile a list of other records or reports used in routine railway operations, included under the above general classifications, for which forms should be designed and included in the Manual. This year the Committee presents nine forms to be designed and included in the Manual. These are set forth on page 578 of Bulletin 313.

In the work of collaboration with other committees and in the design of forms by this Committee, it is evident that the work could proceed with more uniformity if there were adopted general specifications to which the forms thus designed should conform. For this purpose there have been prepared specifications for designing forms, and included therewith also brief specifications for printing, paper, etc. These are shown on page 579 of Bulletin 313.

The Committee has nothing to report on collaboration with other Committees. Your Committee recommends that the report on the assignment covering forms to be designed be received as information and that the collaboration with Committee XII, which has not been completed, be continued.

I move that the Specifications for the Design, Arrangement and Printing of Forms, as reported on pages 579 to 582 of Bulletin 313, be adopted and published in the Manual.

The President:—It is moved and seconded that the Specifications for the Design, Arrangement and Printing of Forms, shown on page 579 of Bulletin 313, be accepted and approved. Are there any observations or questions?

Mr. J. L. Campbell (Northwestern Pacific):—It is not clear whether it is desirable or advisable at this time to begin putting valuation forms into the Manual. The Bureau of Valuation itself does not yet know, in many respects, what these forms should be.

The President:—Pardon me, Mr. Campbell. The Committee wishes me to state that at present they are sticking to page 579, if that is agreeable to you.

Mr. J. L. Campbell:—Excuse me.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—Under Form Number, Item 4, page 579, the Committee recommends that the form number for the particular report be placed in the top corner, left-hand preferred. It appears to me that this is a poor place for the number for the reason that with most files of forms that corner will be pinned down to such an extent that you can not find it. It also destroys the legibility of the number. This is not a very serious matter, of course, but it appears to me that it would be in a little better position if the number be placed in the right-hand corner.

Mr. E. Y. Allen:—This was discussed by the Sub-Committee and it was felt that when a form is filed, the form number is not of further interest. The form number is used only for the purpose of reprinting or reference.

The President:—Are there any further questions on the issue before the house? If not, the voting will be for the adoption of the Specifications for the Design, Arrangement and Printing of Forms as shown on page 579.

(The motion was put to a vote and carried.)

The President:—We now turn to Appendix C, Report Progress Upon Changes or Revisions in I.C.C. Classification of Accounts. This is shown on page 583.

Chairman J. H. Hande:—That is simply a brief report of the progress made in hearings before the Commission and requires no further comment.

Our Appendix D is entitled: "(4) Study and Report progressively upon methods and forms for gathering the necessary data for keeping up to date the physical and valuation records of the property of railroads with respect to: (a) Changes made necessary in government regulations; (b) Simplicity and practicability of use."

This is the subject that was assigned to us by the Board of Direction, and in the absence of Mr. B. A. Bertenshaw, the Chairman of this Sub-Committee, I shall ask Mr. W. R. Kettenring of that Sub-Committee to present the report, which is submitted only as information.

Mr. W. R. Kettenring (Chicago & North Western) :—This report is divided into two parts: Changes Made Necessary on Account of Government Regulations, and Simplicity and Practicability of Use.

The first part of this report deals primarily with Valuation Orders. Supplement No. 4 to Valuation Order No. 3, being the List of Units, is the first list of units required for valuation purposes put out by the Commission. The previous list in use by many roads was put out by the Presidents' Conference Committee after conference with the Bureau of Valuation.

Supplement No. 5 to Valuation Order No. 3, at present the most important order before the railroads, provides for bringing valuation down to date on forms known as B.V. Form 588 with several sub-schedules.

Valuation Order No. 24 provides for the reports required by the Commission on new lines, extensions, and retirement of existing lines.

Valuation Order No. 25 provides for the bringing down to date of the accounting reports of the valuations. The most important schedule in that report from the engineering viewpoint is the reconciliation of the money shown on the Valuation Order No. 3 reports with the investment accounts of the carrier.

We have included in this report several forms which roads may find it desirable to use for records of property changes.

In connection with the returns to Supplement No. 5, Valuation Order No. 3, one of the suggestions contained in that Supplement was to the effect that roads might reduce the number of valuation sections. The Committee canvassed the roads quite generally and found that those in favor of reduction in the valuation sections at the present time constituted a minority of those returning replies to our questionnaire. This is believed by the Committee to be due largely to the fact that many roads have already consolidated their valuation sections and no further consolidation appears to be necessary by many roads.

The entire report of this Sub-Committee is submitted for information only.

Chairman J. H. Hande :—Next is Appendix E, appearing on page 612, entitled: "(5) Report upon Methods and Forms for Handling the Interstate Commerce Commission's Requirements Under Order No. 15100—Depreciation Charges of Steam Railroad Companies."

Mr. C. C. Haire, Chairman of this Sub-Committee, will present the report.

Mr. C. C. Haire (Illinois Central) :—The report of this Sub-Committee is shown in Appendix E on page 612, but owing to the status of the Depreciation Order, this report is necessarily one of progress.

As you all know, the Depreciation Order was a subject of long hearing before Commissioner Eastman of the Interstate Commerce Commission, and this hearing was just concluded last November. As the matter now stands, the Depreciation Order is in effect. The dates of compliance therewith have been removed by a formal order of the Commission.

Commissioner Eastman announced last November, at the conclusion of the hearing, that a tentative finding would be issued later on, and the carriers would be permitted to file briefs and answers thereto before a final order was entered.

The Committee has merely laid the foundation for a future report or reports, and submits as information some historical matter, a bibliography and a brief description of what the Depreciation Order is. It is quite obvious that, in the event of issuance of an order reinstating in the original order certain dates of compliance or a modified order, comprehensive data should be gathered for the use of members of the Association, not only as to the effect of the order, but giving suggested methods to attack the problem.

The Committee will await developments and be prepared to continue its work along these lines. As I said, this report is nothing but a progress report. We have probably just started.

Chairman J. H. Hande:—If there are no comments, we will proceed with Appendix F, page 646, Study Statistical Requirements of the Accounting, Operating or Other Departments with Respect to Maintenance of Way and Structures, and Recommend Reports for Maintenance Foremen which as far as Possible will Reduce the Number Required and Permit Uniformity, Simplicity and Economy.

This is one of a series of studies designed to develop the reports that are necessary in preparing maintenance of way statistics, from the maintenance foremen's reports up through to the final statistics by the engineer of maintenance of way. Mr. E. S. Butler, Chairman of the Sub-Committee, will present this report.

Mr. E. S. Butler (Missouri-Kansas-Texas):—The text of the report is a study of the forms used by track foremen in reporting materials used, and is submitted as information. The form, Exhibit "A," which appears on page 650 of Bulletin 313, is recommended by the Committee for inclusion in the Manual.

I move that this form be included in the Manual.

The President:—It has been moved and seconded that the form appearing on page 650 of Bulletin 313 be acted upon. Is there any discussion or questions? If not, those in favor say "aye"; opposed, "no." It is carried.

Chairman J. H. Hande:—There is called to your attention the conclusion to our report that appears on page 652 with regard to what the field of action of this Committee should be in view of the fact that other organizations are dealing with valuation and depreciation. This may answer Mr. Campbell's question.

Conclusions 2 and 3, appearing on page 652, have been approved by the Committee on Outline of Work of the Board of Direction, and those conclusions are the basis for our work, to which we will strictly adhere. We think that this will avoid any confusion as to what our field should be.

This completes the report of Committee XI.

The President:—Mr. Campbell, have you any observations you wish to make before the Committee is excused?

Mr. J. L. Campbell:—I think not, Mr. President, except that it occurs to me, and I presume it is a fact, that this Committee in its work has the benefit of the expert knowledge and help of the valuation engineers of the railways generally in regard to valuation matters.

Mr. Edwin F. Wendt (Consulting Engineer, Washington, D. C.):—It seems to me very unfortunate that a report such as has been presented by this Committee receives so little discussion. This is one of the most outstanding reports that has ever been presented to this Association. It is worthy of the discussion of an entire day. Of course that is impracticable, but I do wish to commend the Committee, not only for the quality and thoroughness of its work, but for the extent to which the Committee has gone into the field which is covered so incompletely by its title.

I am glad to hear that the Committee expects to consider its work in accordance with the concluding paragraphs of its own report. It seems to me that the Committee should proceed to outline principles and methods according to its good judgment, giving due consideration to the work of other organizations.

The engineer has a peculiar field in which to work in reference to records, reports, accounts, and valuation. This Committee is composed of eminent men who consider not only matters of valuation but the relation of the law and accounting and economics to this question, so that their recommendations are really a textbook on the general subjects which they have covered in this report.

Time is limited and I shall close with the statement that in my opinion their report is an outstanding document. It shows the progress which is now being made in connection with some of the most important phases of railroading, such as the proper classification of accounts in the matter of the investment, the proper definition of depreciation, the correct application of the principles of depreciation to the accounting and the valuation, and many other subjects.

Before this year, 1929, closes, the depreciation order which has been referred to by the Chairman will be issued and then a great opportunity will be presented to the engineer to express his judgment as to the proper principles and methods which should be followed in determining one of the most important aspects of the whole railway work.

I arose, Mr. Chairman, simply to commend the Committee for the excellent work which they have done. (Applause.)

The President:—Are there any more comments on the Committee's work? If not, the Chair wishes to confirm and state to the Association its approbation of the statements of Mr. Wendt. The Association wishes to commend them for their excellent work and the Committee is excused with the thanks of the Association. (Applause.)

DISCUSSION ON BUILDINGS

(For Report, see pp. 549-574)

Chairman Frank R. Judd (Illinois Central):—The report of this Committee is found on page 549 of Bulletin 313, Vol. 30.

There were seven subjects assigned to this Committee. Of these, the Committee reports material for the Manual on two subjects, on one it asks that the subject be discontinued, and reports progress on three subjects.

The three subjects reporting progress are: Specifications for Concrete Used in Railway Buildings; Design and Construction of Water Station Buildings; What Constitutes Appraisal of Fire Losses.

The Committee moves the acceptance of the report of progress on these three subjects.

The President:—The progress reports have been moved and seconded, and I shall assume that the positive vote is cast and they will be received as requested.

Chairman Frank R. Judd:—Subject No. 3 is to Collaborate with Committee XII, Rules and Organization in the Study of Rules and Regulations for Employees of the Buildings Department. A Sub-Committee was appointed on this subject, and a set of rules and regulations were prepared by this Committee. I am glad to say that it was so well done that Committee XII accepted them in their entirety, and yesterday this convention adopted these rules. I am, therefore, quite proud of the work of this Sub-Committee and am recommending that the subject be discontinued.

The first subject covering material for the Manual is Appendix A, and I am asking Mr. Sparks, Chairman of the Sub-Committee, to present this report.

Mr. A. L. Sparks (Missouri-Kansas-Texas Lines):—In Bulletin 313, page 550, Appendix A, you will find a resume of information contained in previous Bulletins concerning building subjects published in the 1921 Manual, and showing additions and revisions to date. This is a condensed index for your benefit.

On the bottom of page 551 are given a number of recommendations for changes in No. 15, Specifications for Railway Buildings. These changes are principally of an editorial nature and require very little comment. The changes recommended are in order to clarify and amplify the present specifications and really do not change in any way the intent of the specifications, as, for instance, in the masonry specifications, stone masonry and cut stone. The specifications for Portland Cement are referred to, and the specifications for sand are repeated rather than referring back to the specification for sand included in brick masonry. The other changes recommended following this are of a similar nature.

Your Committee moves the adoption of this matter for inclusion in the Manual.

The President:—It is moved and seconded that the recommendations be approved for inclusion in the Manual. Attention is called to the fact that the material is not changed fundamentally, but are merely corrections and editorial revisions. Is there any discussion on the motion?

(The motion was put to vote and carried.)

Chairman Frank R. Judd:—The next subject including material for the Manual is Study and Report on Specifications for Buildings for Railway Purposes.

In the absence of Mr. Orrock, I will present this report, which is found in Appendix E, page 554. Last year this Committee presented seven specifications as information and for publication in the Proceedings, namely, concrete paving, wood block paving, wood block flooring, asphalt block paving, asphalt block flooring, macadam paving and asphalt macadam paving.

During the year the Committee has received no adverse criticisms of these specifications, and therefore now moves their adoption for publication in the Manual.

The President:—It is moved and seconded that the list just read be put in the Manual. Is there any discussion on the motion? If not, the list is before you collectively. Those in favor of its adoption will please say "aye"; opposed "no." The "ayes" have it, and it is so ordered.

Chairman Frank R. Judd:—This subject has been continued, and this year the Committee presents as information and for publication in the Proceedings three new specifications, namely, ornamental and miscellaneous metal work, brick paving and flooring and sprinkler system. It is moved that these three specifications be accepted for publication in the Proceedings as information. We hope the Committee will get criticisms during the coming year, so that the specifications can be presented next year for publication in the Manual.

The President:—As it is not desired to be acted on finally this year in the matter of the vote, the Chairman says they are offered to you for criticism, review and comment. Are there any questions you desire to ask in regard to this? It is desirable to register any question or objections on these matters of specifications. The Committee welcomes comments now because next year they desire an affirmative vote. Opportunity is presented now for discussion. There being no discussion, it will be received as information, as stated by the Chairman.

Chairman Frank R. Judd:—The final subject for the Committee is: "Outline of Work for the Ensuing Year," and in addition to the subjects carried over, the Committee offers two new subjects, namely:

(a) "Prepare Recommended Clearance Diagrams for both Main and Subsidiary Tracks adjacent to or entering Building Structures."

(b) "Waterproofing and Dampproofing as applied to Building Construction."

The President:—That will be referred to the Committee on Outline of Work for next year. The Committee state they have nothing else to offer, and are willing to answer any questions desired at this time. If there are any questions, will you please rise? If not, the Association wishes to thank this Committee and appreciates its work. They are excused with the thanks of the Association. (Applause.)

DISCUSSION ON RAIL

(For Report, see pp. 1231-1324)

Chairman Earl Stimson (Baltimore & Ohio) :—The revision of Manual will be presented by Mr. A. F. Blaess, who is Chairman of the Sub-Committee handling that subject.

Mr. A. F. Blaess (Illinois Central) :—The Committee has made a careful study of the matter in the Manual, and the only changes that they have to recommend are those shown on page 1232. It is recommended that paragraph 401 (b-4) reading: "Any variation which would affect the fit of the splice bars will not be allowed," be changed to read: "No change will be allowed in dimensions affecting the fit of splice bars, except that the fishing template approved by the purchaser may stand out not to exceed $\frac{3}{32}$ inch laterally."

Other material for Manual revision proposed by the Committee appears hereinafter in connection with subject (4) Rail Batter, and subject (6) Reconditioning of Battered or Worn Rail Ends.

I might add that inadvertently there was omitted from the recommendation a proposed change that we desire to recommend in connection with the Girder Rail Section.

It is the recommendation of the Committee that all references in the Manual to the adopted Girder Rail Section be revised so that the designated name or section number will, in each case, be in accordance with the following:

1. The first, second and third character of the name or designation shall be the three figures indicating the weight per yard of the section.

2. The fourth and fifth characters shall be the two letters indicating the sponsoring Association of the section, which in this case will be "RE."

3. The sixth character shall be the figure indicating the actual or nominal height in inches, of the section.

4. The seventh character shall be a letter indicating the status of the section as to revisions. The original section being indicated by the letter "A" and the later revisions by B, C, etc.

These are all the changes we have to offer, and I move that they be adopted.

The President:—It is moved and seconded that the presentation just read to you be approved for inclusion in the Manual. Is there any discussion or observation?

(The motion was put to a vote and carried.)

Chairman Earl Stimson:—Under Subject (2) Mill Practice, comes the study of the causes of rail failures and their remedy. The cause of rail failures of the internal fissure type and their relation to mill practice has for years been the subject of much discussion and investigation. The two most interested parties to the rail question, namely, the makers and the users, have gotten together for joint action. The makers are represented by the Rail Manufacturers' Association, and the users by the American Railway Association. As media of contact, the Rail Manufacturers have named their Technical Committee, and the American Railway Association has named your Rail Committee.

These two committees have organized as a joint committee to study the details of mill practice and manufacture as they affect rail quality and rail failures, giving special attention to transverse fissure failures. This organization was effected at a meeting held during the convention two years ago. Since then the work has been carried on by a joint Sub-Committee. Special rails have been made which during their manufacture are subjected to different cooling temperatures, heat treatments, etc., and these rails are now undergoing service tests in track. Sufficient time has not elapsed to enable other than a report of progress to be made at this time.

Several other agencies are conducting investigations of rails and rail steel, and your Committee is keeping in touch with such investigations. Every railroad investigates its own failures to some extent, while several railroads, that are equipped to do so, make very thorough and complete studies of rail failures and obtain valuable results.

It is desired that your joint committee, which is the official agency for this purpose of the American Railway Association and the Rail Manufacturers' Association, be kept advised of what investigations are being made by the railways and what data they have developed and what conclusions they have reached. The Committee may then, perchance, be able to coordinate the activities of the individual railroads with its own activities and a more effective working plan may be established.

To this end all member roads are requested to promptly advise the Committee of the investigations they are making of the causes and remedies of rail failures and of what results they have obtained. Please forward the information through the Chairman of the Rail Committee.

Aside from these service tests that are now going on, the outstanding feature of the Rail Committee's work this year has been the completion and the actual putting into service of the long-heralded Sperry transverse fissure detector car. It has actually become a reality and Mr. Barnes, the Engineer of Tests, who has followed its development in service very closely, will tell you about it.

Mr. W. C. Barnes (Engineer of Tests, Rail Committee):—On page 1236 of Bulletin 315, there appears a paper on this subject which sketches the highlights in the development of Sperry Method of Detection of Transverse Fisssures in Track up to the actual putting of the car in operation. It will be remembered that the development was financed by the American Railway Association on the recommendation of the Rail Committee.

Briefly stated, the method employed consists of passing through the rail to be tested a direct current of approximately 2,000 amperes, and the detection of a change in the direction of the current flow which takes place in the rail when the current is obstructed by such defects as transverse fissures. Anything that will divert that current flow will be picked up by the detector car.

The A.R.A. detector car, which was the first one built by the Sperry organization, was accepted by the Committee on October 2, 1928, and shortly thereafter started on a tour of the country to demonstrate its value. To date this car has tested approximately 1,000 miles of track and in the first 900 miles for which the records have come in, the car has detected more than 121 badly defective rails.

To give you an idea of the character of defects that are discoverable, they are divided somewhat as follows: there were 50 transverse fissures, 29 horizontal fissures (I might say there were more than 29; we quit counting the horizontal fissures), 15 pipe rails, 3 broken rails, 2 cracked webs, 1 broken base, 5 split heads, 1 crushed head, and 15 miscellaneous. On the average there was one defect discovered in about eight miles of track. There was an average of one fissure rail in 18 miles. The maximum with this car was one every three miles, the minimum about one per 100 miles.

The other car that has been operating has a maximum record of something like two transverse fissures to a mile. The great majority of these failures have been verified by breaking of the rail.

The efficiency of detection is something that possibly needs a little discussion. It is a matter very difficult to prove, and I don't think we will get any positive proof until we learn more about the speed of development of transverse fissures in track. Whenever a road uses this car and later on a transverse fissure develops in the track and that transverse fissure was not recorded by the previous test, the question arises as to whether it was a failure of the car to detect that fissure or whether it developed since the test was made. The old idea, based on knowledge that rails occasionally fail due to transverse fissures after twenty years' service, for instance, was that it took possibly twenty years to develop the fissure; that is, the fissure gradually grew during all that time. But the evidence that we are getting of late indicates to me very clearly that that idea is all wrong.

The transverse fissure statistics for this year, which will be presented later, show a total of 114 fissures developed within the first year of service in rail rolled in 1927. Furthermore, I have records which I think give perfect proof of the growth of a transverse fissure in main line track, the first that has ever been watched during the growing process.

A rail was examined from end to end in a most careful manner, field notes and records made, and at one spot in that rail there was a fissure whose area was less than 0.03 of a square inch and that was all that was in that rail. I suppose there might have been something way down in the thousandths beyond our possibility of detection, but that is all there was of that size. Five days less than two months thereafter, another test was made of that same rail and two transverse fissures at that time were present, and their areas were foretold by the test. The rail was broken and the areas corresponded to the forecast.

The one that had measured about 0.03 of a square inch had increased to practically 40 per cent of the head of the rail, and the other fissure, which was not there at the time of the first test, had an area of about 30 per cent. So you can see that these things grow very fast at times and we certainly have to find out more about them.

I think by next year we will have some very interesting data on that subject. The car is being improved from week to week, additional apparatus and equipment is being put on which is improving the speed of detection and the accuracy of detection and the records now made are not at all comparable with those made in the beginning.

With regard to accuracy, I should mention that we had a retest made on a certain road for 85 miles, going over the same track that was tested previously, and in all that 85 miles every flaw detected on the retest appeared on the original record with the exception of one. I think that is an extremely good record.

The President:—Gentlemen, you have heard the very interesting remarks by Mr. Barnes. This is a very vital and interesting subject to the railway industry. Are there any questions to ask him, or any information that he has not extended?

Is Mr. Sperry here? Would Mr. Sperry care to make a few remarks on the subject?

Mr. E. A. Sperry (Sperry Development Company):—I hesitate to take up the time of such a wonderful Committee as we have here. I want to extend the greetings of the American Society of Mechanical Engineers, of which I am President this year, and I want to tell you that we have no such showing as this in our deliberations. With us one sole member of the Committee, the chairman or his representative, gets up and reads his report, but this is my first experience where the whole Committee is lined up to be shot at. It is extremely impressive to me. I certainly feel that the American Railway Engineering Association is to be congratulated on the wonderful way in which they go at their job, and I believe great good is being accomplished.

I am very glad to have an opportunity to say a word about the car, in the development of which all this Committee have been so patient with us all through these years, and great credit is due to them. We have done the best we could to get things started and, as Mr. Barnes has just said, we have only scratched the surface. It is too early, we feel, to make any generalization, but we are finding out many things and it is bound to help the whole general situation as to our knowledge of rail fissures.

There is one quite wonderfully encouraging thing about the way the car handles itself. I might say that one feature is almost accidental. We would of course not have the record at all if the current were not in the rail, and we put such a great big current through the rail that it has to cough up every skeleton in its closet, so we can catch it on the record.

If that current is not in the rail, of course, we cannot find what is inside; we cannot look down through the steel in any other way but by using current. But, fortunately, if the current should fail in any way, two things happen immediately. First, we would not get the great big indication that we get at every rail joint. There is a peculiar record that always comes up through, and our experts, as Mr. Barnes will tell you, can read it almost as well as they can an ammeter and see whether it is 1,800 amperes or 2,100. Secondly, if one can imagine that the current should be present at both rail joints and suffer an eclipse anywhere along the length of the rail, an indication instantly comes through on the record, big in its amplified state. So we know absolutely that we have the current in the rail.

It is comforting to know that that is about all we have to know. If we have that great overpowering current in the rail, if the rail is perfect the current goes, as Mr. Barnes says, perfectly straight down the rail. But if there is the most minute fault in that down in the interior, then the current comes up to that fault and says, "Here is a chasm a mile wide. I will have to go around." Fortunately, we can catch him going around. It comes up on the record and we find exactly what size he is and what kind of a flaw it is.

Science has advanced so that now we can look down through steel, find what is in there, and come up with a neat record of the facts. This is doing considerably better than we could do a few years ago by looking on the outside. We certainly could not get a record of what the things looked like on the outside. Such a method ought to be very useful.

I am proud to have collaborated with this wonderful group here, and am glad if we have made a contribution that will aid in eliminating unsound rails in track.

There is one other thing before I sit down, if you will bear with me a moment more. In the records this year we have a most able paper by a member of this Rail Committee, Mr. W. C. Cushing, on the *genesis* of these transverse fissures. It may be that the time has come when we can commence to write the next chapter, namely, the *exodus* of the rail fissure, and here is the group that will be largely instrumental in doing it. I thank you. (Applause.)

The President:—It is a great pleasure for this Association to hear Mr. Sperry make these remarks to us and we thank him therefor. I wish to say that the Association shares with Mr. Sperry the great respect for this Committee he speaks of. On this Committee are six Past-Presidents and six former Directors working willingly and voluntarily in this rail work.

Chairman Earl Stimson:—I should like to add for Mr. Sperry's benefit that this Committee is just the reverse of the committee he spoke of in his own society, in that on this Committee every man shares in the work, with one exception. That exception is the Chairman; he does no work at all.

While still on this subject I will call upon Mr. Hughes to present his offering. He is Engineer Maintenance of Way of the Rock Island Lines. The Sperry detector car, owned by the American Railway Association, probably had its most successful and spectacular trip on his road.

Mr. L. J. Hughes (Chicago, Rock Island & Pacific):—When we found that we were going to get the detector car to use on our road we selected the piece of track where we had been having the most trouble with transverse fissures. This was 92 miles of rail which was rolled in 1913 and laid on our line which runs west from Memphis. Of that 92 miles of rail, up to December 20, when we began to use the detector car, we had had a total of 110 transverse fissure failures. These failures occurred in 41 heats, and of the 41 heats we had removed seventeen from the track because of having three or more transverse fissure failures in the heats.

This track was on a comparatively light traffic line. The tonnage annually passing over the same during 1928 was 5,493,000 gross ton-miles. The heaviest locomotive that we used on this line was a Consolidation type locomotive of about 100 tons. Thus you will see we had an abnormal number of transverse fissures on comparatively light traffic, so the results that we obtained were most interesting.

Before starting out with the car we determined upon a method of procedure whereby we would keep an accurate record of the results and have our records so that we could refer back at any time and locate any rail on the record as secured. In order to do this we delegated one man whose job it was to sit at the recording table and make all notations on a tape as it passed through. We then had another man who was familiar with the territory who stood in the car and called out the mile-posts, stations, and such topographical features as would enable one to locate oneself on the record later on.

We then decided that we would use a methodical way of examining the indications. We had decided that a three-point indication was what would surely give us transverse fissures, and while that decision was somewhat erroneous, the first trip we made we only examined those indications which were recorded on all three points.

Our method of procedure was this: We started the car moving at six miles per hour and on the first three-point indication we would stop the car and the observer would get out and go back to look at the rail. If there were no evidences of anything on the surface which might cause this indication we gave the signal to have the car back up. We then made a repeat on that same place and secured the same kind of record. If the indication came through the second time we then backed the car up and made the check with the hand galvanometer. You understand that the record as made with the pens is picked up by a device which does not come in contact with the rail, but in making a check by hand we use a method whereby a drop in potential is accurately measured by a millivoltmeter and two terminals spaced about ¾ inch apart are moved over the surface of the rail near the area where the transverse fisssure is supposed to be located. One of these fissures, of course, is located very accurately by the hand galvanometer method.

Proceeding in this way we made our first trip over the 92 miles, and as a result of that first trip we removed a total of thirty-eight rails from the track. We had a work train following behind with a car of rail, and when we would locate a rail in which there was a transverse fissure as indicated positively by the pen method, or for any other purpose we wanted to remove the rail, we would take it out of the track immediately.

As I said, on this first trip we removed a total of thirty-eight rails, of which eighteen were removed on account of visible defects.

It was not necessary to have the machine locate these eighteen rails. They could have been found by anyone. But nevertheless they were picked up and accurately recorded. We removed eleven rails from track where we thought we had an indication of a transverse fissure and where we got some indication with the hand galvanometer, but we broke those rails in the field and failed to find anything the matter.

Then we removed nine rails which we broke, and positively located transverse fissures within the rails. After this trip was made, it was decided to make some changes in the mechanism and to put on a device that would apply pressure to the brushes which put the current into the rail.

At the request of Mr. Barnes we took the machine to our shops at Little Rock, Arkansas, and applied the air cylinders, and then we used the machine and ran it over the same territory. Before we had completed the application of the air devices, we had received word that in this first trip we passed up two transverse fissures, and the rails broke in track after the machine had gone over.

This led us to checking our records, and we found that both of those rails which we passed up, and which broke later under traffic, were indicated by the machine, but we who examined the record made the mistake by calling the indication a burn spot instead of a transverse fissure. One of the chief difficulties in handling this machine is the fact that you get an indication for a burn spot on the top of the rail that is exactly the same or almost exactly the same as the indication you get from a true transverse fissure.

Consequently, if you are running the machine over track that has a considerable number of burned spots on it, great care must be taken in making sure that what you are looking at or what indication you get comes from the burn and not from a transverse fissure.

Being warned by the two fissures which we passed up, you may be sure that we were very, very careful on the second trip. On this second trip we removed a total of twenty-six rails, of which five were taken out on account of pits and visible defects; ten we took out as giving indications of fissure and when we broke them we couldn't find anything; eleven we removed had positive transverse fissures, making a total of twenty-six removed on the second trip.

After this we took the machine to our Kansas Division and went over 100 miles of territory there, so altogether we have made with the machine a total of 287 miles. This 287 miles was covered in eighteen working days, and our average mileage per day was sixteen miles. It cost us $5,192 altogether to run the car. This figures at $18 per mile. The cost per day amounts to about $288. Of course, we used the work train all the time. We had a car of rail along and whenever we wanted to take a rail out we took it out. This could not be the normal way of operating the machine. In normal operation it wouldn't be necessary to follow up with the work train because the arrangement to take the rails out could be made with the section men.

I have some photostatic copies of representative cases of rail removal, and I want briefly to call your attention to two or three of them. I wish I were able to have these put on lantern slides. We were not able to do so, but copies will be available if desired to have them in the publication.

The first one was a rail which is marked on this record as No. 7. A double indication, a three-pen indication, was given and the rail was removed from the track, was raised up and dropped, and a piece broke off nine feet from the end and showed a fissure about 50 per cent in area. From the hand check we found there were two fissures in this rail. The other was about eight inches back of the first one. So by simply hitting the rail with a blow from the spike maul an eight-inch piece was broken off and this double fissure was located quite readily. There were absolutely no marks on the rail to indicate it, and it was a very lucky one to have removed from the track.

The second one which I wish to describe was No. 42, and here is a case where we made a mistake in diagnosing the results as given. This rail should have been removed from track. It is a rail in which we had had three failures, but one of those rails where the heat number was not so plainly visible and consequently it was left in track. We got two indications on that rail. On looking at the chart I see No. 42 is marked, and the second one in that same rail has a ring around it and says "burns." We made a hand check at the first point of No. 42 and we couldn't find any fissure there although we had some indication on the tape. On account of this being a bad heat number, I ordered the rail removed from track and instructed that it be put on the car and shipped in to the laboratory. Before doing so, the roadmaster thought he would see if he couldn't break it anyway. So he raised the rail up and let it drop down, and it broke about nine feet from the other end where there was a bad fissure, the crack extending through to the surface. Our machine indicated that each time. We ran over it twice. The second indication was stronger than the first. The error was made on our part in simply paying attention to the indication at one end of the rail and calling the other a burn spot.

I am mentioning these cases to bring out how careful we must be in analyzing and determining on what we find on the tape.

Another thing that I think is of quite great importance is the fact that we can locate visible defects, pipes, with that machine. We located one in a 90-lb. rail not very old, 1920, and while it showed on the top a slight black streak and very little flattening of the head, we got a decided indication when we passed over it with the machine. For purposes of instruction, more than anything else, we ordered the rail removed from the track and broken at the point where this pipe showed. I have a photograph of that rail here. It is a bad pipe, extends from a point about half an inch below the surface down to about the center of the web. This was a rail of which the ordinary track man would say, "I will watch it for a while." The machine picked it up immediately and we removed it from track.

It seems to me that some advantage can be taken of this machine in the inspection of rail in the mills. We know that it can locate pipe rails in track, and we know that these pipes are in the rails when they come from the mills. It seems to me this Committee can work out something along these lines during the coming year.

To sum up the results of the trip, I will say that we removed a total of eighty-one rails. Of these eighty-one, thirty-five were due to visible defects; 22 were rails where we thought we had a fissure but didn't actually locate them; and 24 were positive transverse fissures. Of these twenty-four, five were double fissures, that is, two fissures in each of the five rails. The twenty-two rails that we thought had fissures are now at our laboratory being examined. It requires a great deal of work to take these rails and break them up and try to locate the fissures. I will say that I had a report that five rails had been examined to date and no fissures were located in those five. I am quite sure in some of the remaining seventeen we will find perhaps small fissures.

The President:—We appreciate very much what Mr. Hughes has said. It is highly interesting and highly pertinent. Have you any questions you wish to ask Mr. Hughes? If not, we would be very glad indeed to have Mr. James E. Howard of the Bureau of Safety, Interstate Commerce Commission, make some observations.

Mr. James E. Howard (Interstate Commerce Commission Bureau of Safety):—This is a resumé or perhaps a Jeremiad. A serious accident occurred in 1911, caused by a broken rail. The type of fracture was an uncommon one at that time. It was a fracture of interior origin in the middle part of the head. The speaker recognized it as due to a component which had not previously been given consideration, namely, the state of internal strain caused by the cold rolling action of the wheels on the running surface of the head.

A definite terminology was needed to signalize this type of fracture, and the term transverse fissure was applied to it. It was not a simple case of bending, since the most remote fibres from the neutral axis, and as a rule the most strained ones, were not those which were ruptured. It was at once evident that the cold rolling strains of compression in the top of the head of the rail were responsible for this type of fracture, a tension fracture in the interior.

To the speaker this seemed so self-evident that to mention it was considered quite sufficient. Why one rail was stronger than another was no part of the question. The fracture was of interior origin because the strains of tension were greatest at the interior of the head. That was and is the explanation of a transverse fissure.

This explanation did not meet with general acceptance. In fact, it didn't meet with any, at least for a time. And doubts were expressed whether fractures were ever formed in any such manner. Twenty to thirty thousand transverse fissures, however, have removed all doubts on the subject, aided by seventeen years to think it over.

In the meantime many fantastic reasons were offered, more than a score of them, for the display of transverse fissures by those who are not prepared to accept the real cause.

Coming down to the present time, is there any chemical composition, or treatment, or weight of rail that will endure track conditions without the formation of transverse fissures, and what is going to be done about those rails which are now in the track, and which are annually displaying transverse fissures by the thousands?

Two accidents due to this type of fracture have cost over a million dollars. It is time for energetic action to be taken; taking out rails of one heat and putting in those of another does not lead anywhere. By no means would it be difficult to settle some of the points of contention, whenever there is disposition to do so.

In regard to a couple of photographs which I have, one of these illustrates a transverse fissure in a rail which caused an accident in the state of Kansas not long ago; the other photograph shows the two ends brought together. The first shows the transverse fissure which was located in Mr. Sperry's laboratory, and was said to be twenty-six inches from the end of the rail. A paint mark was made. The transverse fissure was in the exact center of that white paint mark.

The transverse fissure was brought to the surface by peening with a light hand hammer. After 100 or 200 blows the crack reached the surface and showed its appearance half way across the top of the head and down on the gage side. I knew what could be done, that a hand hammer could bring that fissure to the surface because it had been done on a split head rail. This was an accelerated rate of formation, the disparity in size between a light hand hammer and a locomotive is such that you will all realize the superior chances for a locomotive to do what the hammer did.

The President:—We appreciate Mr. Howard's observations, and I wish to ask if any one here desires to make any observation on what has just been said, or what has occurred in the Committee's report thus far. No more vital question is before railroads and engineers than the question of the transverse fissure matter and the detector car proposition at present. If there is nothing else to be said, Mr. Stimson will continue the report.

Chairman Earl Stimson:—The statistics on Rail Failures are fully given in Appendix B, and we will pass them without formal presentation.

The next subject, (4) "Cause and Prevention of Rail Batter," will be presented by Mr. Hunter McDonald in the absence of Mr. Backes, the Chairman.

Mr. Hunter McDonald (Nashville, Chattanooga & St. Louis):—I am appearing in behalf of the Chairman of this Sub-Committee, Mr. Backes, who is out of the country and requested me to present the report of the Committee. I am familiar only with that part of the report that I have contributed, and Mr. E. W. Backes, who has been assisting Mr. Backes on this Committee, as an observer and engineer for that work, will follow me and outline some of the work that he has had special charge of, and incidentally will introduce a proposed addition to the Manual to cover a new method of making observations for the purpose of gathering statistics.

Regarding the work that I have particular charge of. On page 1269 under the head of "Lubrication," I have reached the conclusion from my own observations without any outside help, that there is no use experimenting any further with oils and greases.

In this same paragraph I refer to the possibilities of lubrication which may be found in the spraying of the ends of the rail behind the joint bar with a "Metalayer" process, with which Mr. Backes is familiar and which is covered in another part of the report. He will probably refer to it when he gets on his feet.

On the same page, reference is made to exhibits, bringing up to date the observations on our Atlanta Division, where we have two sections of 110-lb. rail that has been under observation now for several years with monthly reports.

The diagram showing results of comparison between high and low carbon rails laid opposite each other at Vinings from February, 1926, the date of laying, to October, 1928, appears on page 1279. This indicates no very marked difference between the total amount of battering on the high and low carbon rail. The two are now traveling in lines slightly diverging, the high carbon showing a decreasing rate of battering. The difference between them in October, 1928, was .003 inch. The diagram for low carbon rail only on page 1280 shows a total battering during the same period as above .0295.

There are several paragraphs referring to the position of ties with respect to the joint. I have nothing new to report on that, but hope to have by the end of the next year in our next report.

On the matter in the fifth paragraph from the top on page 1270, we wish to strike out the word "total" in the third line and substitute the word "accumulated" in order that we may not interfere with the use of the word "total" in the proposal for the Manual. By accumulated batter we mean batter that has been welded up once, twice or oftener, as the case may be. In that connection I will say on mile 106, Chattanooga Division, we have welded up 35.7 per cent of the joints once. We weld up after the batter has proceeded to .04 of an inch. We do not weld out of face but weld them up as soon as convenient after they have battered that far. Where you weld more than once, the question of accumulated batter arises, when you wish to make comparison of different rails and the total accumulation is desirable.

In the matter of sawing off the end overflow to prevent chipping, I corresponded with a good many gentlemen but have received no answers or any definite information. I feel that that subject might well be dropped until some one is ready to report his experience on it.

We are still pursuing the plan of sawing after welding in order to eliminate all metal that adheres to the ends of the rail in the joint gap and thereby interferes with expansion. We believe that is a better plan than to depend on chipping it off with a cold chisel. It cost us about 30 cents per joint.

Mr. Chairman, I now yield the floor to Mr. Backes.

Mr. E. W. Backes (Boston & Maine) :—This appendix of the report of the Rail Committee is presented as information except a few recommended changes and additions to the Manual. Though the Sub-Committee has covered this subject quite thoroughly, it still considers there is considerable field for investigation and research. The help of such railroads as can consistently participate in the study and solution of this matter is very necessary if the final findings of the Sub-Committee are to have the value which any work undertaken by this Association deserves.

The causes and other factors related to rail batter have been briefly described and summarized in the report. A brief reference to the spraying of rails and joints with molten metal and the Krupp rail of 1926 is also included.

The taking of rail batter information on various railroads is subject to a large number of variables, which renders the task of tabulating, comparing and drawing conclusions very difficult. For this reason such variables as can should be eliminated, and the following changes and adoptions are for this purpose.

The Manual at present reads as follows:

"Batter.—The distance in 64ths of an inch between the bottom of a straight-edge 12 inches long, applied along the top center line of the rail (with one end coinciding with the end of the rail) and the top of the rail at a point ½ inch from the end of the rail.

"(A) For welding up, resawing and renewal purposes the batter should be measured with a taper gage.

"(B) For statistical purposes the batter should be measured with a micrometer."

It is recommended that this be changed to read as follows:

"Half-Inch Point Batter.—The distance in thousands of an inch between the bottom of a straight-edge 12 to 24 inches long, applied along the center line of the worn surface on the top of the rail (with one end coinciding with the end of the rail) and the top of the rail measured at a point ½ inch from the end of the rail.

"End Batter.—The distance at the end of the rail measured as for half-inch point batter.

"Total Batter.—The sum of half-inch point batter and end batter.

"(A) For welding, resawing and renewal purposes half-inch point batter taken with a taper gage in 64ths of an inch will be sufficient.

"(B) For statistical purposes the batter should be measured with a dial micrometer in thousands of an inch. For uniformity the use of standard batter gage is recommended."

Mr. Hunter McDonald:—I move that the proposal for amendment of the Manual as presented by Mr. Backes be adopted.

The President:—It has been moved and seconded that the amendment shown on page 1271 be adopted. Is there any discussion? If not, those in favor say "aye"; opposed, "no." It is carried.

Mr. E. W. Backes:—There is a print of an instrument published in the Bulletin on page 1277. It is recommended that an instrument of this type having a 24-inch straight-edge and accurate to a thousandth of an inch be adopted as standard.

Mr. Hunter McDonald:—Mr. Backes has proposed a modification of the clause on page 1271. The reason for this is that since this clause as printed was adopted by the Committee, there has come to its notice a gage of similar type, and this amendment will admit of the use of either gage.

I move that the method proposed on page 1271 as presented by Mr. Backes and as amended be adopted.

The President:—It has been moved and seconded that this proposed method be accepted.

(The motion was put to a vote and carried.)

Mr. E. W. Backes:—To further insure the uniformity of results so necessary to an accurate study of the matter, the Sub-Committee also recommends the adoption as standard of the rail batter investigation note sheets, pages 1275 and 1276 of the Proceedings.

The President:—Unless there is an objection, the Chair will rule that the form submitted will be included in the affirmative vote just taken.

Chairman Earl Stimson:—A very interesting report on the Economic Value of Different Sizes of Rail appears as Appendix E. Mr. Blaess will present the report.

Mr. A. F. Blaess:—Report on Subject (5), Study of Economic Value of Different Sizes of Rail, appears as Appendix E of Rail Committee Report and may be found on pages 1291 to 1303, Bulletin No. 315, March, 1928.

A complete report on this subject required both a theoretical and a practical investigation from which deductions could be made and conclusions drawn to make up a chart that would give, by inspection, the most economical size rail to be used under varying track conditions and intensities of traffic.

The report submitted this year is for information only and principally concerns a theoretical study based on progress reports made by special committee of this Association on stresses in railway track. Results of this year's study are shown in a series of graphs, pages 1295 to 1303, which show theoretically and in a relative manner how the various size rails compare with each other.

Attention is called to the fact that each size rail is taken for the same road and under the same conditions so that the charts may be used to determine what per cent or how much better one size rail is than another, thus eliminating any differences of opinion on basic stresses and should be used in the comparison.

It is to be noted that on page 1293 statement is made that theoretically 70-pound rail as unity of track may be bettered by 50 per cent by increase of rail to 136 pounds. Attention is called to Chart H, page 1302, which shows cost of owning and maintaining of rails of various weights under various extensions of track. This chart is given to show how it is desired to present final conclusions and the order in which various observations made from various railroads will have to be handled. It is therefore apparent that this rail study is no one-man study or no one-committee study. Its success lies in the willingness of a great number of carriers to make studies of selected material and furnish additional information to the Rail Committee for consideration and conclusion.

I hope that a sufficient number of the member roads will become sufficiently interested in this to work up the data and furnish the information along the lines suggested in this report. It is not possible for the Committee to make a complete report and draw conclusions unless they get information from other railroads under different conditions in different locations.

We, therefore, solicit your assistance in working this out. Mr. Farrin has done a great deal of detail work on this, and if anyone wants to ask any questions about these graphs and data that have been prepared here, I am sure he will be glad to answer.

I recommend that this report be accepted as a progress report and information.

The President:—It will be so accepted.

Chairman Earl Stimson:—The report of the Sub-Committee on the Reconditioning of Battered or Worn Rail Ends appears as Appendix F and will be presented by Mr. Adams, Chairman of the Sub-Committee.

Mr. Lem Adams (Union Pacific System):—The subject assigned to this Sub-Committee is to "Continue the Study of the Reconditioning of Battered or Worn Rail Ends by the Electric and Oxy-Acetylene Welding Processes, with Especial Reference to the Effect Upon Rail." This report of the Sub-Committee will be found on pages 1303 to 1307 of Bulletin 315.

The Committee presents in Appendix F the final report of the investigation of the effect upon rail steel of reconditioning by the electric and oxy-acetylene processes, and recommends that the following conclusion be approved for printing in the Manual:

"The reconditioning of rail ends by either electric or oxy-acetylene welding has not been found detrimental to the rail. Either method gives an adequate wearing surface to the rail ends when the metal is properly applied. It provides an economical means for restoring battered rail ends to their true surface, and is recommended as good practice."

The Committee moves that this conclusion be accepted and printed in the Manual.

The President:—It has been moved and seconded that the statement on page 1304 at the middle of the page be put in the Manual for printing and adopted as recommended practice. Is there any observation or comment on that?

(The motion was put to a vote and carried.)

Chairman Earl Stimson:—The last subject upon which report is offered is that of tests of alloy steel rails. This report covers the use of intermediate manganese steel rail and is based on information furnished by the railroad using this kind of rail.

As the Chairman of this Sub-Committee is not present we will allow this report to speak for itself.

This concludes the report of this Committee.

The President:—Gentlemen, before excusing the Committee it is proper that I should express for you to them the appreciation of the work and the achievements of this Committee. The Committee needs no recommendation to you and needs no laurels other than what they have accomplished.

Mr. J. L. Campbell (Northwestern Pacific):—Before this Committee is dismissed, I should like to make this suggestion: It might be worth while to consider whether it is practicable to have several rail sections of different weights with common width of base and head.

Perhaps fifteen years ago, on the floor of this convention, Mr. Storey cited an example on his road where they bought new rail of heavier section and found the width of base varied by a fraction of an inch from the width of base of the rail to be replaced, necessitating also replacement of all the tie-plates. This was avoided by having the new rail section rolled with a width of base equal to that of the old rail.

I believe it entirely feasible to make practical application of the suggestion, thereby simplifying the tie-plate problem, with resulting economy.

Mr. E. A. Sperry:—I ask that you bear with me just one more moment before the Committee is discharged, because we have had an experience that may be very profitable to them in the research department.

It was suggested by Mr. Hughes to send to the laboratory these rails that did not seem to have any fissure. We have had this following experience: We had had a very definite indication of a flaw in one of these rails, but very careful searching at the laboratory failed to reveal anything at all, and the specimen was finally put in the discard. But Mr. Drake knew there was something in there, because the electrical method indicated and located it definitely. So we made an assault on the laboratory and said, "Now, you have got to find it." Very much stronger etching methods were then utilized and finally a little crack was found, even though only observable by the microscope (absolutely, you could not see it with the naked eye.) It turned out to be no less than 1½ inches long. So this and other similar experiences led us to believe that the non-destructive method of seeing exactly what is in there possibly had it over the older destructive and more expensive method.

I would advise the Committee here that if they send samples of that kind to their laboratories, to use the strongest kind of etching methods, use the microscope and no end of persistence. I believe in that way the faults found by the electrical method will be checked, because I know electricity never lies and it does not give us definite and identical repeated indications on the record unless there is something there.

The President:—The Committee is excused with the thanks of the Association. (Applause.)

A

DISCUSSION ON ECONOMICS OF RAILWAY LOCATION

(For Report, see pp. 817-892)

Chairman F. R. Layng (Bessemer & Lake Erie):—This report will be found in Bulletin 313, starting with page 817. I will ask Mr. F. E. Wynne to present the first subject to be reported on this year, entitled, "Economics of Railway Location as Affected by the Introduction of Electric Locomotives."

Mr. F. E. Wynne (Westinghouse Electric and Manufacturing Co.):—In the section contributed by this Committee, the Manual now contains data for use in determining the steam locomotive's weight, capacity and fuel consumption. This fact suggested the preparation of similar data for the electric locomotive. Such data are submitted in Appendix A.

Your Committee feels that the increased interest in electrification demands general information for use in preliminary computation. The first three sections of this report pertain to the determination of the minimum required locomotive weight; sections 4 to 8, inclusive, refer to the first approximation of locomotive capacity; section 9 indicates whether the minimum weight and required capacity can be met simultaneously in actual construction and, if not, how the weight must be adjusted to the capacity. Sections 10, 11 and 12 indicate whether the first chosen locomotive capacity is sufficient or is subject to a correction factor, and the amount of such correction which is necessary. Sections 13 to 18, inclusive, show how to find the amount of energy which must be delivered to a locomotive for the specified performance.

I wish to call your attention particularly to the statement in Section 19 on page 825: "The methods and data outlined in this section for the selection of electric locomotives are approximate. However, the results obtained by their use will be sufficiently accurate for a preliminary determination regarding the probable economy of electrification. If such preliminary study indicates that electrification promises the best solution of the problem, a more accurate final study should be made by engineers specially trained in the application of electricity to traction."

Yesterday the Committee on Electricity recommended that the material in our report be referred to the Joint Committee on Electric Traction. In view of that recommendation and because of our desire at all times to promote complete co-operation among these committees, and effective co-ordination of their activities, we withdraw our recommendation that Appendix A be printed in the Manual at this time. Instead, we submit it as information and for the further consideration of the Committee on Electricity, the Joint Committee on Electric Traction and our own Committee on Economics of Railway Location.

The President:—It will be so received.

Chairman F. R. Layng:—The next matter reported on by the Committee this year is Appendix B, page 826, and I will ask Mr. R. S. Marshall, Chairman of this Sub-Committee, to present this material.

Mr. R. S. Marshall (Chesapeake & Ohio):—The subject referred to our Sub-Committee is "Prepare in Form for Convenient Use Essential Operating Data Required for Making Relative Comparisons of Values for Studies of Line and Grade Revisions to Meet Modern Operating Requirements."

I may say, first, that Mr. Layng, Chairman of Committee XVI, asked me to take the chairmanship of this Committee some time last summer, I think in July. We got to work on the matter and prepared the report which you see printed in the Bulletin beginning at page 826 and continuing over to the end of the book, as a basis for discussion in the Sub-Committee.

The Sub-Committee met in December. You will see on page 888 a discussion by Mr. C. P. Howard, a member of the Committee, and also on page 891 a further discussion by Mr. W. L. R. Haines, another member of the Committee, from which you will see that there is some difference of opinion in the Sub-Committee in regard to certain fundamentals involved in this subject.

I wish to make it clear that the report which is Appendix B, is, therefore, to be regarded purely as a progress report, and I ask that it be accepted as information. It seems to me that further description of the report and further discussion of it at this time may be unnecessary.

The President:—Gentlemen, these reports will be received as information, and you cannot but be impressed with the data, and the thought that has been given to this Committee's reports. I am sure you will appreciate what has been accomplished in collecting this data, and I want to make that record here.

The Committee is excused with the many thanks of the Association for the work it has undertaken. The matter of Economics is a vital one just now in all railway operation. (Applause.)

DISCUSSION ON ECONOMICS OF RAILWAY OPERATION

(For Report, see pp. 703-780)

Chairman James M. Farrin (Illinois Central):—The report of Committee XXI—Economics of Railway Operation, will be found on page 703 of Bulletin 313.

First is the revision of the Manual. Upon first consideration we had no revision of the Manual to submit, but since this was printed we received a little revision from Committee X—Signals and Interlocking, of this Association, whereby they propose that the following be substituted in the Manual:

"Where the volume and distribution of traffic on single or multiple track are such as to cause congestion, overtime, or delay to trains, directing the movement of such trains by signal indications in lieu of train orders and timetable superiority is with signals having proper safeguards to control movement of train recommended as safe and as affording a means of increasing the capacity or facilitating the movement of traffic."

This has come to Committee XXI after all of our meetings have been held, and in talking to the various members of the Committee informally as well as I could it seems to be the consensus of opinion that Committee XXI does not want to approve this change in the Manual until it has had time to consider it, which it proposes to do this year.

The next subject is: "(2) Study of Methods for Obtaining a More Intensive Use of Existing Railway Facilities, with Particular Reference to Increasing Carrying Capacity." The report on this subject will be given by Mr. M. F. Mannion, Chairman of the Sub-Committee.

Mr. M. F. Mannion (Bessemer & Lake Erie):—The report of Sub-Committee 1 is found under Appendix A on page 705 of Bulletin 313.

This Committee has reported in the past on the effects of different changes in operation on the economy of transportation. This year the Committee has reported on three different subjects or three different changes in operation, the first one being improved service which has been effected by the railways of this country in the past several years.

On page 706 there is a table which shows some statistics of the railways in the United States. Briefly summarized it can be stated that the railways between 1921 and 1926 have handled 44.4 per cent more freight traffic in 1926 than in 1921, operated 19.4 per cent more freight train-miles, and improved the road time 0.28 hours per 100 freight train-miles.

The Committee has plotted the statistics for the period 1921 to 1927, and these are shown in the graphs on page 707.

The second subject reported on by the Committee is shown under Exhibit A on page 711. This subject is "Method for Determining Most Economical Train Lengths, Considering all Factors Entering into Transportation Costs, such as Fuel, Road Time, Length of Passing Sidings, Per Diem, Etc."

The Committee first went into the discussion of the capacities for a given arrangement of tracks and also discussed the determination of capacities of locomotives. Table III on page 713 shows the maximum grades negotiable by locomotives with various weight trains, that is, the maximum grade over which a locomotive can handle a train five times its weight, seven and one-half times, nine times, and so on.

Table IV shown on page 714 shows the average speed and related fuel consumption per hour for various weights of trains.

The Committee then plotted the actual train-hour diagrams for the section of road that was studied, and they are shown in Fig. 3 and Fig. 4. The train-hour diagrams were then simplified and are plotted in performance charts which are shown on pages 719 and 720.

Then the data was analyzed in order to determine which was the most economical weight of train to handle. The performance diagrams, as mentioned before, shown in Fig. 5 and Fig. 6, were then transposed to the charts shown on page 723, and these projected to the lower section of Fig. 7, which shows that in this case the most economical train which could be handled under the conditions prevailing on this section of road was between eleven and twelve times the weight of the locomotive.

In the latter part of the report, the Committee has endeavored to show a comparison of several of the operating costs. It also shows a comparison of the theoretical capacity with the capacity which is actually being obtained.

They also show the fuel consumption and wage cost. On page 733, three different cases of theoretical examples were worked out and the charts on page 723 show the train-hour costs for each of the different plans.

The third subject reported on by the Sub-Committee was the study and report on improvements made on a heavy track North and South railroad. This railroad is 345 miles, and is divided into three operating divisions of which the northern division, 122 miles, is the most important as a traffic carrier. Freight traffic on the northern division increased 60 per cent from 1921 to 1924, and in order to take care of this enormous increase in traffic, the division was double tracked, 43 miles of double track being installed.

The first part of the report states the operating statistics for the entire road, and the performance charts are shown in Fig. 1 on page 741 and Fig. 2 on page 743. The train-hour diagrams are also shown in Fig. 4 on page 749.

The northern division was then analyzed by itself and the performance charts for the northern division are shown on page 752, Fig. 6. The operating results and economies which were shown for the northern division are also shown for the entire road. Naturally, this should be the case as the northern division was the heaviest traffic division of the entire system and was the only one which was practically being used to its capacity.

The conclusions for the last subject are shown on page 753: "The above analysis shows that the construction of double track, along with the slight grade reductions made, practically doubled the capacity of the railway. All the increased capacity did not result from the additional track, as the grade reductions made possible an increase in loading. This increased capacity made it possible for the railway to accept all the tonnage offered and to handle same more efficiently than before double track was installed. The increase of 55 per cent in gross ton-miles per crew-hour will result in operating economies that justify the expenditures necessary to obtain this increased capacity."

The Committee wishes to offer this report as information and recommends that the subject be continued.

The President:—It will be so received and referred to the Committee on Outline of Work.

Chairman J. M. Farrin:—The next subject, No. 3, Continue the Study of Methods or Formulas for the Solution of Special Problems Relating to More Economical and Efficient Railway Operation. This subject will be given by Mr. Teal.

Mr. J. E. Teal (Chesapeake & Ohio):—Appendix B is found on pages 754 to 761 of Bulletin 313. The special problem assigned to the Committee for the current year was to "Study the Effect of the Increasing Capacity of Engine Tenders on the Economical Spacing of Water Stations and the Cost of Railway Operation."

"Gross ton-miles per train-hour" is recognized as one of the most significant units in operating statistics and is a comprehensive index of freight-train operating efficiency. An increase in gross ton-miles per train-hour may be brought about by:

(1) Increasing the train load without effecting a decrease in the average speed of trains between terminals.

(2) Accelerate the train movement between terminals by eliminating stops or by increasing the speed.

Freight-train stops for water and fuel materially contribute to increasing the average time of trains between terminals and consequently to increasing the cost of train operation. Some of the items that contribute to increasing the cost of train operation because of water and fuel stops are listed on the bottom of page 754, items A to K, inclusive.

We do not believe it is practical to state all costs that result from water stops, as a number of them are intangible and may vary between wide ranges, depending upon local operating conditions and traffic density.

In this connection, this Committee presented a formula or method of determining the cost of stopping and starting trains, which was published as Appendix B, page 473, Volume 28 of the Association Proceedings, and subsequently it was reduced to abbreviated form and authorized to be printed in the Manual of recommended practice.

On page 755 is listed a number of items which cover delays to heavy tonnage freight trains at water and fuel stations, items A to F, inclusive.

A study of available printed matter on the subject of using larger engine tanks revealed that there was very little authentic information to be had, particularly as to what other railroads were doing, and in order to obtain some information the Sub-Committee prepared a questionnaire which is shown on page 756, questions 1 to 6, inclusive. This questionnaire was sent out to a number of representative railroads and replies were received from ten, having an aggregate of 47,920 miles of road operated. These roads were located in various parts of the United States.

The information was received in considerable detail, in fact too much to publish, and it was summarized in tabulated form shown and printed on page 761. This table covered replies to questions 1 to 4, inclusive. A summary of the replies to questions 5 and 6 is shown for the ten railroads from the bottom of page 756 to page 758. The results from this questionnaire are summarized and shown on the bottom of page 759.

The information indicates:

"1. Railroads have been changing from small to large engine tenders since 1918. The greater number of changes were in 1926 and 1927. Engine tenders having capacity of from 7,000 gallons to 12,000 gallons were replaced with larger tenders. The largest tender in service has a capacity of 21,700 gallons of water and 26 tons of coal. Other sizes range from 10,000 gallons water capacity and from 18 to 24 tons of coal.

"2. Larger engine tenders effected an increase in the average maximum distance between water stops of from 37 miles to 61 miles, or 73 per cent.

The average minimum distance between water stops increased from 16 miles to 35 miles or 119 per cent. The average maximum distance between fuel stops increased from 69 miles to 102 miles, or 48 per cent. The average minimum distance increased from 53 miles to 58 miles, or 10 per cent.

"3. The average number of water and fuel stops eliminated by the use of large tenders was 2.7 and 1.4, respectively, for each engine run.

"4. The average length of engine district in the study is 150 miles."

This figure may possibly be an error as the information did not show whether the length of engine runs embraced more than one crew distance or not. There happened to be two or three engine runs of considerable length, 400 miles and more.

"5. Average freight train load—4,550 tons.

"6. Average tractive power of locomotives—85,500 lb.

"7. Average time saved per water stop—26 minutes.

"8. Average time saved per fuel stop—19 minutes.

"9. Average pounds of fuel saved per water stop—910.

"10. Average gallons of water saved per water stop—770."

The Sub-Committee wishes to continue this study another year with a view of endeavoring to translate if possible the information into the value of the time saved per water or fuel stop.

The President:—The same is received with much interest and as information.

Mr. C. R. Knowles (Illinois Central):—The report of the Committee is an excellent one and I think they are to be commended for their work.

I want to call attention, however, to the report of the Water Service Committee of last year on Economical Spacing of Water Stations, in connection with large engine tenders, which appeared on page 194, Vol. 29. At that time exceptions were taken to the report of our Committee giving the approximate coal waste at one-half ton per train-stop. The statement was made on the floor at that time that 400 pounds would more nearly represent the average. I note the Committee report this year shows an average of 910 pounds of fuel saved per water-stop. I call attention to this fact because it would indicate that the figures given in our report last year were approximately correct.

Again I want to commend the Committee for the report. I am glad to see they have asked that the subject be re-assigned for further study.

The President:—Thank you very much, Mr. Knowles.

Chairman J. M. Farrin:—With reference to that 910 pounds, I should like to call Mr. Knowles' attention to the fact that the average tractive engine given that consumed 910 pounds was 85,500. I was the one who made those remarks about your Committee last year, and we were speaking of the average for the railroads of the United States, not for an average of a railroad that is using engines having tractive effort over 80,000 pounds. It makes quite a little bit of difference.

Mr. C. R. Knowles:—Our Committee did not consider the average tonnage of all trains throughout the country. It is obvious that the average tonnage would be much lower than 10,000 tons. I believe the average tonnage is about 7500 tons in this report.

This brings up a thought in my mind that we should consider the question of spacing of water stations and large engine tenders not from the standpoint of eliminating water stations, because the real saving to be made is not in reducing the number of water stations, but in eliminating the unnecessary stops. It does not make any difference whether you continue in service the same number of stations you have now or reduce the number The important factor is to provide sufficient water carrying capacity to avoid unnecessary stops because the cost of operation and maintenance of water stations is a mere bagatelle compared to the cost of stopping trains.

Chairman J. M. Farrin:—The next subject, No. 4. No report is being made on this subject this year.

No. 5, Continue the Study of Suitable Units for Operating and Equipment Statistics, etc. No report is made on this subject this year.

The next subject, No. 6, Continue the Study of What Volume or Other Conditions of Business or Service Justifies a Change from Flat Switching to the Hump Method in any Given Yard, collaborating with Committee XIV—Yards and Terminals, is given in Appendix E. The Chairman of that Sub-Committee, Mr. Pringle, will present this report.

Mr. J. F. Pringle (Canadian National):—Report of the Sub-Committee is found on page 762, Bulletin 313. The Committee last year submitted as information a summary of answers received from questionnaires sent out to different roads on the question of cost of switching in flat and hump yards. This year further detailed information was obtained from certain roads and that has been tabulated and is shown on pages 764 and 765 as information.

From a study of this data, the Committee came to the conclusion that it was impossible to give a definite answer in terms of volume or other conditions, but certain limiting features could be pointed out, and we have proceeded to do that in the report, and also indicate the methods by which comparisons of hump yards and flat yard switching could be made.

This report is simply given as information this year, and the Committee recommends that the subject be continued.

The President:—It will be received and assigned to the proper Board Committee for handling.

Chairman J. M. Farrin:—The next subject, No. 7, Continue the Study of Problems of Railway Operation as affected by the Introduction of Motor Trucks and Bus Lines, with particular reference to its Effect upon Branch or Feeder Lines, is given in Appendix F.

Mr. Steinberger, of the Baltimore & Ohio Railroad, being Chairman of this Sub-Committee and unable to be present, the report on same will be given by Miss Olive W. Dennis.

The President:—Miss Dennis will present the report.

Miss Olive W. Dennis (Baltimore & Ohio):—The report of Sub-Committee 7 is found in Appendix F on page 769 of Bulletin 313.

In the preparation of this report, your Committee has endeavored to summarize briefly the recent developments in motor highway vehicle transportation throughout the United States. It should be remembered in examining this report, that it attempts to cover a subject which is changing very rapidly. Data accumulated for publication in November must, of necessity, be almost a year out of date when presented to this body for consideration in March.

For the past two years the reports of this Committee have shown the losses in railway revenue due to highway competition. At first these losses were felt largely upon the branch lines only, but in recent years long distance competition has made itself felt to the extent that we not only show a decrease in total passenger revenue for the railroads, along with a decrease in the total number of passengers carried, but for the first time the average distance traveled per passenger has begun to decrease.

The report gives, first, certain figures showing the amazing growth in recent years in the production and use of motor vehicles, and the great increase in expenditures for highway construction. These are given on pages 769 and 770. At the top of page 771 are listed what seem to be the most important reasons for the popularity of the motor vehicle as compared with the railroad train. Following, at the middle of page 771, are given the four general steps which have been taken by the railroads so far in an attempt to meet this highway competition. None of these has been particularly successful except the last.

The first was an attempt to suppress highway competition by opposition, before public utility commissions, to the granting of permits to independent operators. Such a method could hardly hope to be successful indefinitely, and recent decisions of the courts and public service commissions have indicated that, if the public desires motor transportation and the railroad refuses to give, it is then the duty of the public service commission to grant permits to independent operators.

The second method advocated by certain railroads was an attempt to get legislation regulating the motor carriers with regard to rates, schedules, taxes, and so forth. Some of these railroads are now embarrassed by this legislation in cases where they themselves are attempting to operate motor lines in that territory.

The third method has been an attempt to incorporate in rail service those features which were found attractive in highway motor service or to offset them with other compensating attractions. With regard to frequency of service, which was one of the advantages of the motor coach, some of the railroads between certain points have consolidated their services so that while each railroad gives less service, the timing of trains for all roads gives a more frequent service for the traveling public.

With regard to lower rates: Experiments in reduced rates for excursions have generally shown that this method alone will not attract back to the rails any traffic which has been lost to the highway.

With regard to the rail motor car, the experience has been that it in general reduces the railroad operating expense, but has very little effect in attracting passengers back to the rails who have been traveling by the motor coach.

The last method is one which is being adopted by an increasing number of railroads, and that is the adoption of motor vehicles by the railroads as part of their own service. At the top of page 775 are given the figures showing the number of railroads in 1927 and 1928, which were using motor vehicles as part of their own service; also the extent to which these vehicles were being used and the uses to which they were being put.

The report concludes with the description of seven methods used by railroads in the handling of freight by L.C.L. containers.

With regard to airplane competition the Committee has gathered considerable information, but wishes to report only progress at the present time in this phase of its investigations.

The report of the Sub-Committee is offered for information. (Applause.)

The President:—This report is received as information from Miss Dennis. I wish to say in behalf of the Association that it was presented ably, clearly and concisely, indicating a thorough knowledge of the subject.

May I further take the opportunity to state that in the thirty years of our existence this presentation marks something new in the annals of this engineering association. Miss Dennis is the first lady to have presented to this Association an engineering report, and in recognition of that will you please stand a moment?

(The audience arose and applauded.)

Chairman J. M. Farrin:—I also want to add that our Committee has had a great deal of valuable help and advice from Miss Dennis.

The next subject, No. 8, "Study and develop most economical train length, considering all factors entering into transportation costs, such as fuel, road time, length of passing sidings, per diem, etc.," has already been covered as a part of No. 2.

The next subject, No. 9, "Study economies resulting from use of Radio Telephones for long freight trains and for yard work," will not be reported on this year.

Mr. President, that concludes our report.

The President:—This Committee has made and is making a record. We wish to thank them for their excellent report and to excuse them with the appreciation of the Association. (Applause.)

DISCUSSION ON ECONOMICS OF RAILWAY LABOR

(For Report, see pp. 1105-1144)

Chairman A. N. Reece (Kansas City Southern) :—The report of Committee XXII—Economics of Railway Labor, is published in Bulletin 314, beginning on page 1105.

No revision of the Manual is recommended.

The report on "Methods for Securing Greater Efficiency and Economy in the Use of Labor-Saving Devices in Railway Track Maintenance," will be presented by Mr. F. M. Thomson for Mr. G. M. O'Rourke, the Sub-Committee Chairman, who is unavoidably absent.

Mr. F. M. Thomson (Missouri-Kansas-Texas Lines) :—This report is contained on pages 1107 to 1134, inclusive.

Your Committee has by direct inquiry and questionnaire assembled data concerning economies to be derived from the use of machinery and devices for saving labor. A summary of machines studied during the past year is given on pages 1108 to 1134, inclusive, in Bulletin 314. Some of the information is contained in reports on this subject in previous years.

During the past year the Committee has confined its study to the following devices:

1. Rail laying machines.
2. Rail oiling devices (for preventing corrosion).
3. The advantages of operating in pairs or in multiple units, machines such as ditchers, rail loaders, ballast cleaners, etc.
4. Labor-saving devices operated off track. Among the devices considered under this classification are:
    1. Caterpillar cranes and shovels.
    2. Motor trucks and motor truck cranes for handling material in congested yards.
    3. Paint sprayers.
    4. Post hole diggers.

1. Rail Laying Machines.—There are several types of rail laying machines in use and when compared with other methods of rail laying the economies are greatly in favor of these devices.

2. Rail Oiling Devices (for Preventing Corrosion).—Investigation of these devices indicates that they are justified by results obtained.

3. The Advantages of Operating in Pairs or in Multiple Units, Machines, Such as Ditchers, Rail Loaders, Ballast Cleaners, Etc.—Data assembled indicates that much economy may be effected by operation of certain machines in tandem or in multiple units.

4. Labor-Saving Devices Operated Off Track.—The operation of off-track labor-saving devices is in the preliminary stage and their use has not advanced to the point where comparative studies of economies may be fully developed.

A direct comparison of performance of labor-saving devices on two or more railways shows a wide variation in cost, undoubtedly due to the following:

1. The different conditions under which the operation is performed, frequency of interruption, and restriction imposed by traffic.

2. Character of material handled.

3. Capacity and condition of the machine performing the work.

The conclusions are as follows:

"1. That labor-saving machines and devices carefully selected, efficiently manned, properly supervised and maintained, are productive of substantial economies in maintenance of way operation, and their use is recommended.

"2. Their economy is determined by comparison of the costs of the labor-saving operation with other methods or practices. It should be emphasized that savings effected on one railroad cannot consistently be compared with results on another road, or even upon one division, because of the many variables, such as traffic density, methods of operation, and other conditions which must be considered."

The Committee recommends that this report be received as information and the subject closed, and that further efforts should be directed towards the study of other phases of the problem of effecting economics in the use of maintenance of way labor.

The President:—It will be so received, with thanks.

Chairman A. N. Reece:—Our next assignment is "Standardization of Parts and Accessories for Railway Maintenance Motor Cars." This subject requires co-operation with the motor car manufacturers and several meetings have been held. At this time only progress is reported.

The President:—It will be referred to the Committee on Outline of Work for consideration next year.

Chairman A. N. Reece:—The report on "Equating Track Values for Labor Distribution" will be presented by Mr. F. S. Schwinn, Sub-Committee Chairman.

Mr. F. S. Schwinn (Missouri Pacific):—Replies to inquiries addressed to a large number of railroads during the past two years indicate that about half of the railroads in this country have adopted the practice of equating track values, using all or a part of the list of comparative values or equivalents suggested in the 1922 report of this Committee and published on page 685, Vol. 23, of the Proceedings. The following items are most commonly used:

"One mile of first main track is equivalent to:

1.15 miles of second main track,
1.33 miles of third or fourth main track,
2.00 miles of branch line track,
2.00 miles of passing and thoroughfare track,
3.33 miles of yard tracks,
12 main track switches,
20 side track switches.

Some of the carriers include other items, such as railroad crossings, city street crossings, county road crossings, track pans, ditches, fences, interlocking plants, derails, station grounds, water and fuel stations, stock pens and chutes, slides, etc., which are assigned various equivalent values.

It is thought that the items tabulated above are sufficient for all practical purposes in equating the physical property to equivalent main line miles and that additional equivalents made necessary by local conditions should be established by individual lines.

Your Committee appreciates that in addition to a summation of equated mileage found on the several divisions of a railroad, consideration must be given, in distributing labor, to the comparative present condition of each division, the condition to be ultimately attained, comparative volume of traffic, differences in climatic conditions, grades, curvature, drainage, and other features that would have a bearing on the amount of track labor required.

This Committee, as well as the Committee on Track (Vol. 18, page 420), has in previous years made analyses of the distribution of track labor for various classes of maintenance of way work. Such analyses, while interesting, do not point to definite conclusions as to proper percentages of track labor to be assigned for each operation. Here, again, the differences such as traffic, climate, location, age or physical condition of the property, and other factors, must govern.

An investigation was undertaken to determine the amount of track labor employed in track and roadway maintenance on railroads in the United States, based on annual reports of the Interstate Commerce Commission on Statistics of Railways, for the four years, 1923 to 1926, inclusive. From these statistics we have secured approximately accurate total of mileage, gross ton-miles, and man-hours of track labor, by districts; converting the operated mileage and other property to a reasonably correct estimation of equated mileage, by using the equivalents hereinbefore referred to. The item of Track Labor was separated as between the accounts Roadway Maintenance, and Track Laying and Surfacing, and further divided as between the "affected by use" and "not affected by use," in accordance with the recommendations of the Committee on Economics of Railway Operation (Vol. 24, page 1058).

The results of this investigation are tabulated below. I will not take the trouble at this time to read the tables, but merely refer to the next page where an analysis is given of the foregoing tabulations:

(a) Approximately 43 per cent more track labor "not affected by use" was worked per equated mile in the Eastern District, and 50 per cent more in the Southern, than was worked in the Western District.

(b) Track labor "affected by use," per million gross ton-miles, was 14 per cent more in the Southern, and 21 per cent more in the Western, than was worked in the Eastern District.

(c) Upon converting man-hours to men (including foremen) worked per working day per equated mile, it was found that the amount of labor worked, both as "affected by use" and "not affected by use," was approximately 50 per cent more in the Eastern than in the Western District.

(d) If the traffic density in the Western and Southern Districts were increased to equal that of the Eastern District, the average number of men (including foremen) per working day per equated mile would be increased to the extent that it would equal that of the Eastern District.

The conclusions for insertion in the Manual are:

"(1) Recommended practice for equating the physical property of a railroad to equivalent main line miles

"One mile of first main track is equivalent to:

"1.15 miles of second main track,
"1.33 miles of third or fourth main track,
"2.00 miles of branch line track,
"2.00 miles of passing and thoroughfare track,
"3.33 miles of yard tracks,
"12 main track switches,
'"20 side track switches.

"To this list there may be added such other items as may be required, and the equivalents as so determined should be adjusted by factors relating to present condition, traffic density, speed of trains, seasonal or climatic conditions, grades, curvature, drainage, and the ultimate standard of maintenance desired.

"(2) That this subject be closed."

Chairman A. N. Reece:—I make a motion that the conclusions recommended for publication in the Manual be accepted.

Mr. J. E. Willoughby (Atlantic Coast Line):—I trust that the Committee will not insist that this table as given be inserted as recommended practice. The table as indicated from the text preceding is an average of the United States and as information is valuable, but for a man to say that one mile of first main track is equivalent to two miles of branch line track without further information is nonsense, because there is every character of branch line track and there is every character of main line track. If the Committee will take the conclusion which is proposed to put in the Manual as recommended practice and insert also a large amount of the information which goes before, none of us would be deluded with the idea that a mile of main track is equal to two miles of branch line.

The President:—I understand Mr. Willoughby's objection to this report is he is not willing in his vote for this table to go in unless it is explained in a part preceding in the Manual. As an isolated report, Mr. Willoughby is not in accord with that plan. The matter is now open for discussion.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—I had much the same thought that Mr. Willoughby had, except that I want to go this much farther: The average figures for the whole United States are probably correct for the whole United States but accurately correct for no one location. I do not believe this should go in the Manual.

Mr. C. C. Cook (Baltimore & Ohio):—Perhaps I can clear it by stating that it is already in the Manual. It was approved in connection with the report on standard methods for performing maintenance of way work for the purpose of establishing units of measure of work performed. That was, I think, in the year 1923.

The President:—As it now stands, it appears in the Manual. The

Chairman of the Committee says the reason for asking this is so that it may reappear in connection with his report. Of course if Mr. Willoughby's motion should come up for deletion and elision from the Manual, it will take another action. The question now is a matter of repetition. I take it that we could vote this in this report, if affirmative, or quote the information. You have the issue in two events. It is now before you under a recommendation of this Committee to present these conclusions to be comprehended in this report.

Mr. C. W. Baldridge:—We have been making considerable effort for the last three or four years to reduce matter in the Manual to keep it within reasonable size, and if this matter is already in the Manual I see no reason for putting it there again.

Chairman A. N. Reece:—We are willing to eliminate the recommendation for publication in the Manual and submit the report as information only.

The President:—Gentlemen, you have heard the willingness to not take the action referred to and therefore I withdraw the call for the vote.

Mr. V. R. Walling (Chicago & Western Indiana)—These units as far as they go are very valuable information. For terminal railroads it would be of very great assistance and help if the Committee could carry forward their investigation to include such important items as railroad crossings and slip switches. For my part, I should very much dislike to see this subject closed without their making an investigation and submitting to the convention later their recommendations for those important items.

The President:—I shall ask the Committee on Outline of Work to take under consideration the recommendation made by the Sub-Committee and also by the Chicago & Western Indiana representative.

Chairman A. N. Reece:—The report on "The Economic Ratio of Supervision to Labor," will be presented by Mr. H. A. Cassil, Sub-Committee Chairman.

Mr. H. A. Cassil (Pere Marquette):—In making this study of the Economic Ratio of Supervision to Labor the best method of approach seemed to be the securing of data from the various Class I railroads in order to see what was practical in that respect. The Committee sent a questionnaire to all the Class I railroads and were very much gratified by the prompt and comprehensive replies that were received. Upon receipt of this information it was placed in tabulated form and appears as an insert following Appendix D, page 1139, Bulletin 314.

We found that direct comparisons could not be made between the railroads due to radically divergent local conditions, but the averages derived give valuable information from a sufficient number of widely varying railroads to form a suitable and reasonable basis for comparison.

I might say that the aggregate total of mileage represented is nearly 160,000 miles and this does not comprise the full mileage, as some of the reports from the larger railroads included only a portion of their mileage.

There is one interesting development that we found after we had tabulated this information and obtained the averages. All of the men who have had to deal definitely and minutely with track will remember that six miles was considered as a section of track for a section track gang, and in this average we reduced to almost exactly that mileage for an average gang.

We gave considerable time and thought to the making of recommendations as to what might be done in deciding the proper ratio of supervision to labor, but found it rather impracticable for reasons that are mentioned in the report. I might read the summary on page 1140:

"The organizations, as reflected by addenda to this report, have been built up through many years of experience and in many instances were originally worked out in their present form when traffic was much lighter, speed slower, standards of maintenance less exacting, weight of equipment much less, and practically all maintenance of way work was performed by manual labor. With the reverse of these conditions and the use of labor-saving devices, which requires added supervision, and the varying conditions on different roads, it would be extremely difficult to establish a definite relation between supervision and labor that would be applicable to all railroads.

"It is the conclusion of your Committee that the ratio of supervision to labor is an individual problem for each railroad, and that the data in this report be applied by making suitable equations for individual lines by those most familiar with their own requirements."

This report is offered as information to the Association.

The President:—Thank you very much, Mr. Cassil, for the information and the report.

Chairman A. N. Reece:—Mr. Lem Adams, Sub-Committee Chairman, will present the report on "Practical Education and Training of the Individual Workman in his Assigned Duties as a Means of Securing an Increased Output and Better Quality of Work, with Less Effort and Fewer Accidents."

Mr. Lem Adams (Union Pacific):—This report will be found under Appendix E, page 1141, Bulletin 314. This information was received through questionnaires addressed to a large number of railroads throughout the country, and several government agencies having to do with educational training. As time is short I will just read the summary:

"Summarizing, your Committee feels that a great improvement is badly needed and can be made in the instruction of embryo mechanics in the Maintenance of Way Department. It is our thought that an efficient track employee is a tradesman, experienced in the use of a large variety of tools and trained in placing various kinds of material, under changing conditions of traffic, foundation and climate. A track laborer should have at least two years' experience to become proficient in this kind of work, and to acquire proficiency in this length of time he must have exceptional opportunities and be unusually apt and willing to learn.

"This subject is of such general nature that your Committee does not consider it advisable to make definite recommendations for standard methods of performing each item of Maintenance of Way work; therefore, it is recommended that the foregoing report be accepted as information and the assignment continued for further study."

Chairman A. N. Reece:—This completes the Committee's report.

The President:—I wish to thank this Committee on behalf of the Association, and excuse them with the appreciation of the Association. (Applause.)

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